

Naqui, Farzawa

PhD

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**GE-PAK: A Computable General Equilibrium Model of Energy-Economy
Interaction in Pakistan**

**A thesis submitted for the degree of
DOCTOR OF PHILOSOPHY**

by

Farzana Naqvi

B.A. (Punjab), M. Sc. (Islamabad)

**Department of Economics
University of Sydney**

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Summary

Like many developing countries, Pakistan is a net importer of energy products. The government administers prices of three major forms of commercial energy: petroleum products, natural gas and electricity. In setting energy prices, it aims to foster social equity and economic growth, to control the balance of trade and to generate revenues. As a result of these multiple objectives, there are various distortions in energy prices: some users and fuels are favoured above others. The effects of removing these distortions on an economy can best be analysed in a general equilibrium framework that incorporates energy-economy interactions in detail. The major objective of this thesis is to develop such an applied general equilibrium model of Pakistan. We apply this model to simulate the short-run effects of removing the distortions in energy prices. In our analysis of the simulated effects, we focus on the micro- and macro-economic effects and the distributional effects. An index is constructed to show the overall effects on welfare of the society. Finally, we compute the elasticities of welfare cost with respect to indirect taxes for energy products.

A major contribution of this thesis is the development of GE-PAK; a computable-general-equilibrium model of energy-economy interactions in Pakistan. The model incorporates a detailed production structure of the Pakistan economy, incorporating 128 industries (including several energy industries) producing 132 commodities. The model also embodies many types of primary factor. Fourteen household-groups are distinguished (7 urban and 7 rural). Major features of the model include detailed modelling of energy industries (particularly electricity sector); substitution pattern of energy inputs in current production; inter-region labour migration; and incomes of households and government.

In Pakistan, there are various distortions in energy prices. Our first step is to quantify these distortions. We review the prices of three major energy products and found three types of discriminating tax: source-, product- and user-discriminating taxes. We apply GE-PAK to simulate the effects of removing these

three discriminations in the short run. The simulation results help us to answer two questions. (i) What are the macro- and micro-economic impacts of removing these distortions in the taxes on energy products? (ii) What are the distributional implications of such reforms? In reporting the economic effects, we focus on selected impacts (such as effects on real GDP, real private consumption, the balance of trade and sectoral outputs) which are of major concern to policy makers and planners. However, more detailed results help us to understand the mechanisms through which these impacts emerge. The results for real *per capita* consumption by 14 types of household help to analyse distributional effects from various angles. The income-distributional effects are analysed both across income groups and across regions. The variations in real *per capita* consumption among the 14 types of household are due to variations in (i) their sources of income, (ii) their pattern of consumption, and (iii) inter-region migration. We decompose the effects of real *per capita* consumption for the household groups into the above mentioned three components. This helps us to understand variations in real *per capita* consumption in the results.

The effect on society's welfare depends on the weighting given to the welfare of the various groups. Since the effects on real *per capita* consumption are not uniform, we construct a social welfare index which computes the weighted-average of the effects on the consumption for 14 types of household. For this aggregation, we use Atkinson's welfare function. We compute the social welfare indices with and without inequality aversion. One of the major concerns in any tax reform is its effect on indirect tax revenues. We use these indices to compute the elasticities of welfare cost with respect to indirect tax revenues. The elasticities are computed for an increase in the tax on the individual major energy products. We use these elasticities to rank energy products accordingly. This ranking shows us two things. (i) Which energy products are better candidates to increase indirect tax revenues if we take into account their social welfare costs? (ii) Does the ranking of commodities change when we take into account the distributional effects?

Statement of Authorship

Except where reference is made in the text of this thesis, this thesis contains no material published elsewhere or extracted whole or in part from a thesis presented by me for another degree or diploma

No other person's work has been used without due acknowledgment in the main text of the thesis.

This thesis has not been submitted for the award of any other degree or diploma in any other tertiary institution.

Farzana Naqvi

September, 1994

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ACRONYMS

AGE	Applied General Equilibrium
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
CIF	Cost, Insurance, Freight
CPI	Consumer Price Index
DGNRER	Directorate General of New and Renewable Energy Resources
FOB	Freight on Board
GE	General Equilibrium
GE-PAK	Computable General Equilibrium model of Energy-Economy Interaction in Pakistan
GEMPACK	General Equilibrium Modelling Package
GDP	Gross Domestic Product
GNP	Gross National Product
GOP	Government of Pakistan
HSSW	Harberger-Scarf-Shoven-Whalley
IEA	International Energy Agency
IMF	International Monetary Fund
KWH	Kilo Watt Hours
LES	Linear Expenditure System
MCFT	Million Cubic Feet
MSG	Multi Sectoral Growth
OCAC	Oil Companies Advisory Committee
PDB	Pakistan's Data Base
Rs	Pakistani Rupees
ROW	Rest of the World
SAM	Social Accounting Matrix
TOE	Tonnes of Oil Equivalent
WAPDA	Water and Power Development Authority
WPI	Wholesales Price Index

Chapter 1

Introduction

1.1 Energy Planning Issues in Pakistan

Pakistan maintained a high economic growth rate during the last two decades. Over this period the average rate of economic growth was 6.0 per cent *per annum*. Due to the high population growth rate, however, *per capita* income grew at only 2.9 per cent *per annum*. Pakistan continues to rank amongst the low-income developing countries.

Pakistan's economy has been characterised by three phenomena since 1970. The first two, associated with changing political regimes, relate to the role of the public sector. During the first six years of the 1970s, most large industries were nationalised and massive public investments (with large gestation periods) were undertaken in the manufacturing sector (most notably steel). The government that came to power in 1977 sought to reverse this trend by shifting emphasis back to the private sector¹. The third phenomenon relates to the two world oil price shocks. Despite the change in political regimes and the impact of the oil price shocks, energy² policy in Pakistan has changed very little since 1970.

¹ Since 1977 the liberalization of the economy has been on the planning agenda of Pakistan (GOP, 1992). This includes liberal trade policy, privatization of major nationalised industries and de-regulation of many other parts of the economy.

² Throughout this thesis, energy or energy products refer to marketed products extracted from conventional energy sources, and their processed forms. For Pakistan, these products include crude petroleum, raw natural gas, coal, hydro electricity, petroleum products, natural gas (processed raw natural gas) and thermal electricity. We refer to crude petroleum as oil and raw natural gas as gas.

Pakistan is a net importer of energy. The energy supply and its price are managed by the government. The functioning of the energy industries and most of the related industries are mainly regulated by government policy and plans. The public sector supplies, or directly supervises the supply of, all commercial energy products—apart from coal. Much effort has been devoted in Pakistan to the formulation of energy policy. The scope of such planning varies from the design of an integrated energy plan to the appraisal of a single project. A number of problems and policy issues are faced by the energy planners. These problems are similar to those faced by all the developing countries who are net importers of energy:

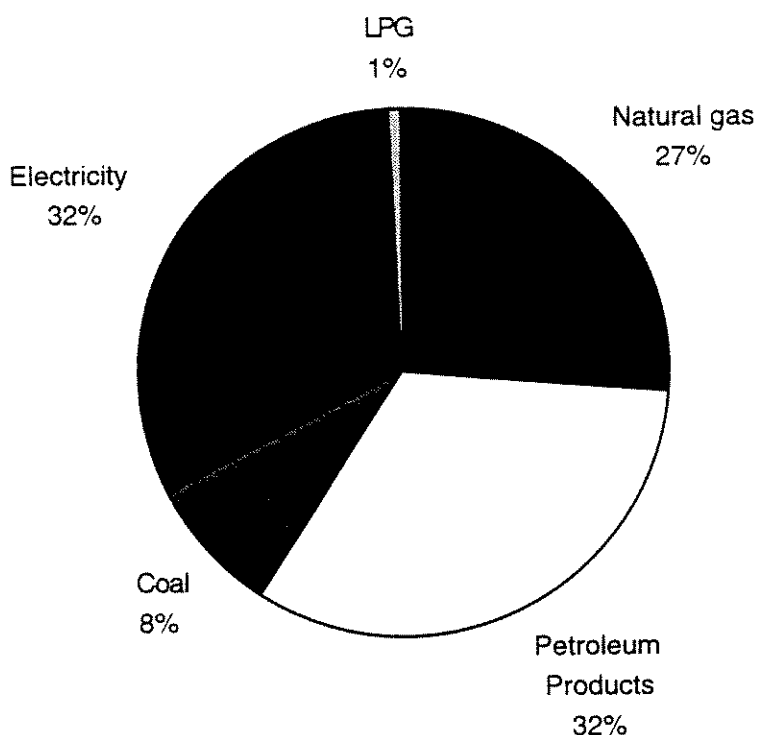
- (i) rapidly growing energy demand,
- (ii) setting of energy prices,
- (iii) small energy resource base,
- (iv) high investment requirement for energy projects,
- (v) continued high dependence on imported oil, and
- (vi) capacity shortage in the electricity sector.

Due to the constraints on energy supply, most of the planning efforts in Pakistan have been directed towards energy supply planning — in particular towards expansion in electricity supply. All investment funds in the electricity sector come from the public budget, government guaranteed loans from international agencies, or from the electricity utility's own revenues³.

Figure 1.1 shows the shares of energy products in total energy consumption of Pakistan in 1990-91 (GOP, 1993). Petroleum products and electricity have the highest shares (32 per cent for each) in total consumption. Natural gas has the second biggest share (27 per cent) while the share of coal is very small (10 per cent).

³ Recently, private sector involvement is being encouraged in electricity generation and transmission (GOP, 1992); however, until now all investment in the electricity sector has come from public sources.

Figure 1.1 Shares of Energy Products in Total Energy Consumption
(1990-91)



Thus petroleum products, electricity and natural gas are the major sources of commercial energy demand. The supplies and prices of these 3 types of energy products are administered by the government. Within the energy sector, public corporations and private companies work under government-regulated energy prices and profit margins. The public sector also has a significant share in the production of cement and chemical fertilisers. The production processes of both these commodities are energy intensive. Their prices are also set by the government.

Coal mining is the only energy industry in which the private sector has a large share of production and investment. Market forces determine the consumption, production, and pricing of coal. A small quantity of coal is produced in the public sector and its price is set in line with the market price. However, coal has a dwindling share in total commercial energy consumption;

its share declined to about 8 per cent in 1991-92 (GOP, 1992a) from about 15 per cent in 1971-72.

The prices of petroleum products, natural gas and electricity are administered by the government to promote equity, to stabilise prices (of both energy and other commodities), to generate revenue, to manage the balance of trade. As a result, energy prices diverge from the levels which would be obtained under a free-market regime. It is possible to think of these divergences as a series of implicit taxes and subsidies on energy products. After the 1970s and 1980s' oil price crises, some studies were carried out to analyse and estimate the level and nature of distortions in administered energy prices in the developing countries (for example Sidayyo, 1983; Sidayyo, 1988; and Kosmo, 1989). For Pakistan, two such studies were carried out. Kuijper (1982) examined petroleum products prices of 1979-80 while Sabih (1986) analysed electricity pricing. These studies were carried out in a partial equilibrium framework to compute the social welfare loss arising from distortions in energy prices. Although such analyses are important to estimate the inefficiencies of regulated energy prices and the resultant loss to society, their scope is limited. Most importantly, such analyses do not evaluate the micro and macro economic impact of removing the distortions from regulated energy prices. Further, due to the partial equilibrium framework, complex energy-economy inter-relationships are overlooked. Last but not least, such analyses do not show to what extent the distortions in energy prices (in the form of implicit subsidies and taxes) actually further the above listed multiple objectives.

It is generally accepted that energy prices play a major role in macro economics in the long-run. Only after the first oil shock in 1973, energy pricing policies were given their due weight in the short run by all countries; developed or developing. As discussed by Sarkar and Kadeokdi (1988), energy prices affect the economy in various ways which we now discuss.

Energy plays a dual role of consumption good and intermediate input. It is demanded both for direct use (private consumption) and indirect use (input into production and transportation). Besides income, the major determinants of

energy demand from households are the prices of energy and non-energy commodities. In the first round, increase in energy prices reduces real expenditure of households. The reduction in households' demands reduces the demand for labour and real wages decline. On the supply side there are two effects on the production costs of all commodities: (i) an increase in the production costs due to rise in the prices of energy which are used as an intermediate inputs and (ii) a decline to the reduction in the wages. Thus there are changes in prices of all commodities depending on many factors such as the labour and energy intensities in each industry and substitution possibilities between energy and capital or labour. The changes in prices of exports affect their demand, and changes in the prices of import-competing and non-traded commodities affect the households' consumption pattern. This feedback effects from the consumption changes the production pattern of the industries. The ultimate impact on the economy in terms of real GDP, balance of trade and indirect taxes is the net of all these effects.

Household income is mainly generated from primary factor employment in production. In the short run changes in output prices (from the demand side) relative to the cost of production determine demand for labour. Labour wages and the level of employment in various industries then depend on labour market conditions and labour intensities in these industries. Since in the short run capital stock is fixed, changes in output prices and production level affect the rental value of capital stock in the production sectors. Thus income of households changes with change in energy prices.

Indirect taxes and surpluses from the public corporations are the major sources of government income. Since both production and pricing of energy products are under government control, the surpluses from these activities and from other activities using government-owned capital accrue to government as contributions from public enterprises. Changes in prices and demand for non-energy commodities will affect government revenue from indirect taxes on these commodities. Government also has to pay more as its own consumption cost increases with increased prices. All these elements determine the overall budget

deficit. Therefore, the revenue implication of energy price changes should be analysed in the light of these linkages.

Changes in domestic prices and demand affect the trade balance as demands for exports and imports are affected by changes in domestic prices relative to foreign prices. Management of the trade deficit is one of the major tasks of the government and the effects of energy price changes on the deficit should be analysed.

Turning to the equity objectives, the cost of the consumption bundle of the poorer section of society is one of the major considerations in the administered pricing policy of the Pakistan government. As pointed out earlier, changes in energy prices affect factor incomes in a complicated way. Changes in household incomes along with changes in the prices of commodities affect real consumption of households. This aspect ought to be analysed carefully for any purposeful evaluation of energy pricing policy.

The discussion so far shows that energy pricing issues cannot be looked at in isolation. A general equilibrium model which considers the immense complexity of the linkages of the economy is required.

Further, the regulated energy prices have multiple announced objectives and hence any reform or proposed changes in energy prices should be analysed considering their effects on all these objectives. A general equilibrium analysis allows us to simultaneously examine all the effects of any reform in energy prices on the various objectives in a consistent framework.

1.2 Objectives of the Thesis

The major objective of this thesis is the construction and computer implementation of a computable general equilibrium model of energy-economy interactions in Pakistan. The second objective is to study energy pricing policy in Pakistan. This study focuses on three questions. What are the objectives of energy pricing policy in Pakistan? How far do prevailing energy prices achieve the objectives of energy pricing policy? What is the economic cost of achieving these objectives? First, we review energy prices in Pakistan. In this review we

estimate distortions in energy prices in the form of various implicit taxes, inferring the objectives behind these distortions. We then apply the model to address the last two questions. We evaluate the short-run effects of hypothetical reforms in energy prices within a general equilibrium framework. Conversely, the simulation results will show how far energy pricing achieves its objectives of energy pricing policy, along with other micro and macro economic effects. In brief, there are three tasks to be done:

- (i) construction and implementation of a Computable General Equilibrium (CGE) model of Pakistan incorporating energy-economy interactions;
- (ii) estimation of distortions in energy prices in Pakistan; and
- (iii) application of the model to analyse effects of removing these distortions.

1.3 Survey of Developments in CGE Models

This section briefly surveys CGE models in general and energy models in particular. CGE modelling is a growing and vibrant area of applied economics. The objective here is not to provide a comprehensive discussion of a model of a particular type, but to introduce various types of CGE models. Neither will a comprehensive bibliography be provided⁴ but rather only citations to illustrative works. The focus here is on CGE models of the 'neo-classical' type. We divide this section into two parts. In Subsection 1.3.1, we discuss distinct approaches to applied general equilibrium modelling and introduce the CGE model developed for Pakistan in this thesis. We list the main features of the model to show its commonality with the approaches discussed for CGE modelling. In Subsection 1.3.2, we give a brief survey of general equilibrium approaches to energy policy modelling, again fitting our own model into a wider perspective.

1.3.1 Approaches in General Equilibrium Modelling

In a recent survey Bergman (1990a) reviewed developments in CGE modelling. Bergman focused on a number of distinct approaches to applied general equilibrium modelling. The survey identifies four main branches of CGE

⁴ See Bandara (1989) for a complete list of CGE models for developing countries.

models on the basis of their main characteristics and uses. In the following paragraphs we briefly discuss these four major approaches.

Johansen's Multi Sectoral Growth (MSG) model (1960) is essentially a model of the sectoral allocation of capital and labour as well as of the distribution of sectoral output between uses. Models using the Johansen approach originate largely from the literature on economic planning and input-output analysis. The two branches of CGE models originating from Johansen's MSG model are: (i) ORANI and its various versions⁵; and (ii) CGE models for developing countries focussing mainly on income distribution issues. Adelman and Robinson's study (1978) on *Income Distribution Policy in Developing Countries* exemplifies the latter branch of CGE models⁶.

Harberger-Scarf-Shoven-Whalley (HSSW) models⁷ have their roots in applied welfare economics. Bergman points out three differences between models from this category and MSG/ORANI models. The first difference is in the level of disaggregation of the household sector. A typical model in the HSSW approach explicitly incorporates two or more households and for that reason includes a specification of the initial endowments and the determination of the budget constraints of each type of household. The second difference is related to the type of applications for which the models are intended. HSSW models are to a

⁵ Powell and Lawson (1990) have cited many applications of ORANI in their selective bibliography of Australian computable general equilibrium policy analysis.

⁶ As pointed out by Bergman (1990a), the emphasis on income distribution issues remains a typical feature of most of the models in this branch of CGE modelling, although a number of studies have dealt with trade policy and other aspects of economic policy in developing countries.

⁷ The first to use this approach was Harberger's (1962) numerical two-sector model on the incidence of taxation. The second is Scarf's computer algorithm (1967) for numerical determination of the equilibrium of a Walrasian system. The third is the work on the proof of the existence of, and computational procedure for finding, a general equilibrium with taxes (Shoven and Whalley, 1973). Shoven and Whalley (1972) and Shoven and Whalley (1984) are examples of this type of GE models.

large extent aimed at evaluating policy changes in terms of both efficiency and income distribution effects. Moreover these effects are usually expressed in terms of a one-dimensional welfare measure such as the Hicksian compensating or equivalent variation. The third major difference is related to the way in which Walrasian general equilibrium theory is incorporated in the model. The MSG/ORANI models incorporate some features of the real world which makes them deviate, in the strict sense, from Walrasian general equilibrium theory while HSSW models can be regarded, to a large extent, as the numerical counterpart of the Walrasian general equilibrium model. An example of a large-scale application of this type of model is Piggott and Whalley's study (1977) of the tax and subsidy system of the UK. Due to its disaggregated representation of the household sector (100 types of household) the authors were able to elucidate the income distribution effects of a series of hypothetical tax changes.

The third approach to CGE modelling is the econometric estimation approach applied by Jorgenson (1982). The fourth approach is due to Ginsburgh and Waelbroeck (1981) and can be characterised as an extension of activity analysis and linear programming modelling.

An Introduction to GE-PAK

The General Equilibrium model for Pakistan developed in this study (from now on called GE-PAK) belongs to the class of MSG/ORANI models and is in the spirit of ORANI — a CGE model of the Australian economy (see Dixon, Parmenter, Sutton and Vincent, 1982). However it also incorporates some features of the models from the HSSW category. In the following paragraphs, we briefly describe the main features of GE-PAK and its application in this study to identify its commonality with CGE models in other categories. The main features of GE-PAK are as follows.

- (1) Multiple-output industries and multiple-industry commodities.
- (2) Multiple household types.
- (3) Income mapping equations for multiple households and three other institutions.

- (4) Disaggregation of the labour market into urban and rural regions and an inter-region labour migration function.
- (5) Various types of indirect tax variable including user-commodity discriminating taxes and implicit taxes on commodities with regulated prices.
- (6) Multi-level production structures
- (7) Five types of production structure that incorporate factor-energy and inter-energy products substitutions.
- (8) A two-level nested electricity supply structure.
- (9) A social welfare index which is used to compute elasticity of the social welfare cost with respect to indirect tax revenues; generated when we increase tax on a commodity.

In this study the model has been applied to address the income distributional effects of reforms in energy prices, as well as aggregate efficiency effects and sectoral effects. Thus, GE-PAK shares many distinguished features of other CGE models as well as of ORANI.

1.3.2 General Equilibrium Approaches in Energy Policy Modelling

In this subsection, we give an overview of GE approaches in energy policy modelling. This review is based on two surveys. Bergman (1988) made a survey of development in energy-economy models based essentially on general equilibrium theory and the neo-classical theory of economic growth. Bergman's survey covers energy-economy models for developed countries and it elucidates the extent to which details of energy sector are modelled in a GE framework. Devarajan (1988) made a surveyed the application of CGE models to questions of natural resources and taxation in developing countries. In this subsection we present findings from the two surveys and comment on the significance of GE-PAK and its application in this study.

Bergman (1988) has identified 3 categories of numerical models developed to address energy policy issues.

- (a) Optimisation models: Numerically implemented optimisation models have been used for investment and operation planning by firms in the petroleum and electricity sectors.
- (b) Energy-System Models: These models treat the entire energy sector as an integrated system. Nordhaus (1974) and IEA's MARKAL (see Marcuse, Bodin, Cherniavsky and Sanborn, 1976)⁸ are example of energy-system models. Bergman classifies these models as simple partial equilibrium models; usually specified as linear programming models. For an exogenously given vector of final demand for 'useful energy', an energy-system model endogenously determines the cost-minimising pattern of energy resource extraction, conversion and energy distribution. Bergman states that these models have two weaknesses despite of their quite detailed treatment of the energy system technology. The economic determinants of the demand for 'useful energy' and the mutual interdependence of the energy system and the rest of the economy are essentially neglected in these models. Thus, these models have little to say about the impact of changes in energy supply conditions or domestic energy policies on relative prices and the allocation of resources in a national economy.
- (c) Energy-Economy models: These models are based on general equilibrium theory and the neo-classical theory of economic growth. Much of the public concern on energy issues is related to the possible impact of changing energy supply conditions on broadly defined welfare measures. Accordingly, these models provide information about how relative product and factor prices and allocation of resources might be affected by increasing energy costs, by technological change in the energy sector, or

⁸ Fishbone, Giesen, Goldstein, Hymmen, Stocks, Wilde, Zolcher, Balzer and Abilock (1983) present a user's guide of the computer implementation of this model. A recent work on this model is integration of MARKAL and ETA-Macro model of Manne (1977) in Hamilton, Goldstein, Lee, Manne, Marcuse, Morris and Wene (1992).

by various energy policy measures. Bergman has reviewed a set of energy-economy models within the CGE tradition. These models are grouped into two categories: (a) Models with specific approaches to the treatment of energy demand within a CGE framework; and (b) models with a more elaborate treatment of energy supply. Bergman identified four models in the first category: (i) Hudson-Jorgenson's model (1975) of the US economy; (ii) the MSG-4 model of the Norwegian economy (Longva, Lorentsen and Olsen, 1985); (iii) a CGE model of Swedish economy (Bergman, 1978); and (iv) the ELIAS model (Bergman, 1986). In the second category, Bergman discusses ETA-Macro model (Manne, 1977) which incorporates a more elaborated treatment of energy supply technologies in a CGE model. In this model an activity or process analysis model of the energy sector is integrated with a model of the rest of the economy. According to Bergman, the integrated models presented in Jorgenson (1982) and Lundgren (1985) are variant of the same approach. Lundgren's model is an elaborated version of the ELIAS model except that the neo-classical production function of the electricity sector in the ELIAS model is replaced by a linear activity model of that sector. Most of these models have been applied to analyse the long-term impact of changes in energy supply conditions. For example, the energy CGE model of Sweden has been applied to elucidate the impact on the Swedish economy of a zero-energy-growth strategy (Bergman, 1978). This application made two projections of the development of the Swedish economy between 1980 and 2000. The study used aggregate real consumption as a rough measure of welfare. The Hudson-Jorgenson model (1975) was used both for projection and policy analysis. Bergman (1990a) reported the policy simulation results showing the impact of a strategy aimed at eliminating US energy imports in ten years time. In general thrust, the results of the two studies show that changes in energy supply and energy consumption patterns take place without much slowing of aggregate economic growth.

According to Bergman, the structure of CGE models intended for energy policy analysis need not differ much from CGE models in general. However, the representation of the substitutability of different inputs has to be more elaborate in an energy CGE model.

Bergman asserts that energy-economy models of the GE type are useful for two reasons: (1) The first is related to the capability of these models to test the Gross Domestic Product (GDP) growth and energy consumption relation. The notion of a generally constant relation between energy consumption and GDP growth cannot be justified by basic economic theory; indeed it can be rejected on empirical grounds through CGE applications. (2) The second reason is that a CGE model has the capability to show the mechanisms through which a change in energy policy affects the economy; *i.e.*, it provides a rather detailed picture of the operation of a number of substitution mechanisms in the economy.

Devarajan also surveyed energy CGE models. Similar to the energy-economy models discussed by Bergman (1988), these models are applied to explicate the energy-economy relation. However, Devarajan focussed on the models for developing countries and grouped them according to their application for two issues: natural resources and taxation. The CGE model applications to natural resource questions are put into three categories: (1) energy management models that highlight the role of natural resources as inputs into the production processes; (2) Dutch-disease models that capture the effects of the windfall that accrues to exporters when the price of oil rises; and (3) optimal-depletion models that take into account the exhaustibility of the resource and the link between optimal extraction and investment decisions. Devarajan classified CGE applications for taxation into two groups: (1) positive analysis, which sheds light on the link between fiscal and trade policies and the impact of tax change on prices and incomes; (2) normative analysis, which computes 'optimal taxes' in revenue-constrained economies. These 'optimal-taxes' are found to be at variance with proposals for tax reforms that are based on rules of thumb.

Examples of energy-management models of developing countries include those of Blitzer and Eckaus (1983a), Blitzer (1986), de Lucia and Jacoby (1982)

and Hughes (1986a, 1986b). These and other energy management models are surveyed by Kim (1986). Another use of these models is for determination of domestic fuel prices. Hughes (1986a, 1986b) and Dixit and Newbery (1984) illustrate how the 'optimal' domestic price need not be the fuel-equivalent world price because of second-best considerations. Thus, when there are other distortions in the economy, the optimal domestic fuel price may involve a tax or subsidy to compensate for these other distortions.

According to Devarajan (1988) there are two weaknesses of these models of the energy-management type. First, in contrast to the detailed treatment these energy models give to the energy sector they treat the rest of the economy in a fairly coarse fashion. The feedback effects between the rest of the economy and the energy sector, are either missing or rather weak. For example, these models suggest that income in the non-energy sector and energy sector affects the demand for energy but that energy prices have no effect this income. Most of the models do not distinguish between the government's and the private sector's budget constraints. Thus, the effects of variation in tax revenues (often associated with changes in energy price) are not captured. The second weakness of these models is that they generally have little connection with the theory of international trade. A large number of models assume that the economy is closed to foreign trade at the margin. In some models the economy is 'semi-open' as some imported energy sources compete, albeit, imperfectly with domestic sources. Even so, these models do not capture the implications of the trade deficit on the economy (through appreciation of the real exchange rate).

Examples of Dutch-disease models are Corden and Neary (1982), and Benjamin, Devarajan and Weiner (1989). These models provide a useful and interesting picture of what will happen to an economy in response to a boom in its natural resource sector. They do not by themselves, however, provide much insight into the types of policy that a government should pursue.

Optimal-depletion models are essentially inter-temporal Dutch-disease models. The oil depletion problem would be independent of the rest of the economy, if the capital markets were perfect. Assuming capital markets are not

perfect, these models tie the depletion question with the economy's borrowing and investment strategies. Devarajan discussed the application of such a model by Martin and Wijnbergen (1986). These models are powerful tools to simultaneously discuss a country's resource depletion, foreign borrowing, and investment strategies. According to Devarajan, however, these models hit computational constraints, requiring the modellers to keep the intra-temporal aspect of the model rather simple. Most of these models, therefore, have no more than two or three sectors.

As pointed out by Devarajan (1988), the issues of taxation in developing countries are different from that of the developed countries for three reasons. (1) Limited administrative capacity prevents most developing countries from instituting a consumption tax, or even a viable income tax. Therefore indirect taxes are the more commonly used instruments. The assumption frequently made in exercises with developed country models, that the tax revenues are rebated in a lump-sum fashion can no longer be made. After all, if the government has access to lump-sum transfers, it should also be able to levy lump-sum taxes. Hence, the revenue implications of tax reform become crucial. (2) The effects of a tax change on the distribution of income are clearly important for the developing countries. (3) Since most developing countries are open economies, the impact of tax reform on foreign trade deserves attention. According to Devarajan, only recently have CGE models of developing countries looked at all aspects of tax reform, namely, the welfare, revenue, equity and foreign trade implications.

The method of examining tax questions with CGE models can be described as either positive or normative. The former simply asks 'what if' questions; the latter attempts to derive optimal taxes for a given economy. For the first category, Devarajan discussed two models; Devarajan and de Melo (1987) and Bovenberg (1987). Normative models can be viewed as positive models with an objective function; 'optimal tax' is defined in terms of the objective function. For example Diamond and Mirrlees (1971) used the utility of consumption in their objective function. It is well-known that lump-sum taxes are the least distorting,

but, as mentioned, they are almost impossible to administer. Diamond and Mirrlees (1971) have shown that without lump-sum taxes the second best instrument is consumer taxes. In many developing countries, however, even consumer taxes are difficult to administer. In this case, a whole array of indirect taxes (producer taxes, export taxes and import tariffs) has to be used. Devarajan points out two problems with the normative model. The first problem is of making inter-personal utility comparisons. The second problem is: if consumption includes only today's consumption, the model attempts to impose a huge tax on investment goods (which are not consumed today). There are two ways to address this problem: to impose a constraint on the taxation of investment goods or to include future consumption as an argument in the objective function. Dahl, Devarajan, and Wijnbergen (1986) adopted the former solution in their effort to compute 'third-best' optimal taxes using a CGE model of Cameroon.

Significance of GE-PAK

In the light of this survey, GE-PAK stands out as an energy-economy interaction model that overcomes many of the weaknesses of previous energy-economy interaction models for developing countries. According to Bergman (1988) a CGE model intended for energy policy should represent the substitutability of different inputs in detail. In GE-PAK, the energy sector is treated in detail. There are two multiple-output energy industries (oil & gas and refinery) while there are four electricity industries each representing a type of electricity technology. The model also incorporates various types of production structure that allow substitution between energy and factors of production and between energy products. In our study, we apply GE-PAK to analyse energy pricing policy in Pakistan. As stated by Bergman, the usefulness of the energy GE model is its capability to show the mechanisms through which a change in energy policy affects the economy. Thus in our study, for example, the model enables us to trace the factors which affect real consumption of 14 types of household for various hypothetical reforms in energy prices. The model gives detail information about the effects on various components of nominal income,

consumption patterns and the Consumer Price Index (CPI) for each household type separately.

Devarajan (1988) pointed out two weaknesses of most of the energy-economy models applied to the developing countries. First, their coarse treatment of the economy apart from the energy sector weakens the feedback effects from the rest of economy for any policy simulation. Second, there is little connection in these models with the theory of international trade. Unlike most of these models, GE-PAK treats all the sectors of the economy in detail. It includes 128 industries and 14 types of household. The model allows imperfect substitution between domestic and imported commodities and incorporates downward sloping export demand curves for the major exports. Thus in GE-PAK, any change in domestic policy or in the world market effects relative commodity and factor prices and has full feedback effects on both household income and expenditure. In our study we simulate the effects of hypothetical reforms in source-, commodity-, and user-discriminating taxes on energy products.

As pointed out by Devarajan (1988), the issues of taxes can be addressed in a positive or a normative fashion. In our study we examine the taxes on energy products in a positive fashion. We analyse economy-wide effects of any change in these taxes on the economy. We focus on particular variables which are connected to announced government objectives. Our analysis simply asks the question "Does the energy pricing policy serve its announced objectives?"

1.4 Outline of the Thesis

In Chapter 2 we review energy pricing policy in Pakistan. We analyse historical growth rates in regulated energy prices during 1971-1988, estimate implicit and explicit taxes on energy prices in the base year and discuss differences in these tax rates across energy products and consumer categories. Since the objectives of energy pricing are not given precisely by the government, this review helps us to infer these objectives. We formulate a scenario of reforms in energy prices based on the distortions in the tax structure.

In Chapter 3 we review some of the studies on energy pricing issues carried out for Pakistan in a general equilibrium framework and some energy-economy models of developing countries. This review is divided into two parts. In the first part we present three studies carried out for Pakistan on energy pricing issues using different types of model. In the second part we present the main features of some energy-economy interaction models of developing countries which relate to our own study.

In Chapter 4 we present the theoretical structure of GE-PAK. We discuss in detail the structure of the model and its equations. The model's equations are divided into 31 blocks; a section is devoted to discuss each block of equations. We list these blocks of equations in Appendix C for a ready reference. Apart from these equations, there are sets of equations that are discussed in Section 4.14. These equations describe five alternative sets of production structures; each corresponding to a set of industries. Further, there is a default production structure. In Appendix C, we list equations for the default production structure instead of listing all five sets of equations describing the five alternative production structures. This makes easier for us to count numbers of equations and variables, and to close the model.

In Chapter 5 we discuss the data base of our model and the values of its parameters. Dhanani (1986) developed a Social Accounting Matrix (SAM) of Pakistan for 1983-84. We have modified and expanded it into a data base which is appropriate for our model. In the first part of Chapter 5 we briefly discuss the SAM and then discuss our modifications in detail. A set of diagrams shows the layout of our data base and the links between various parts of it. In the second part of Chapter 5 we list the parameters of our model and the values assigned to them. We present a brief survey of the literature from which we have borrowed our parameter values.

In Chapter 6 we present and interpret simulation results of various hypothetical reforms in energy prices. To evaluate the effects of reforms in energy prices, we carry out 21 experiments. In these experiments, we simulate the effects of removing source-, product- and user-discriminating taxes on

petroleum products, electricity and natural gas. Conversely, the simulation results indicate the role of these discriminatory taxes in achieving the objectives of the energy pricing policy. In the first section of this chapter we discuss the short-run closure of the model; this determines the macro economic environment of our experiments.

In this thesis, we apply GE-PAK to analyse energy pricing policy in Pakistan. In the final chapter, we summarise our major findings. We discuss other possible applications of the model. We summarise the major features of GE-PAK and its limitations, and suggest directions for future research.

Chapter 2

Energy Pricing in Pakistan

2.1 Introduction

The objective of this chapter is to review energy pricing policy in Pakistan. As mentioned, the prices of three major commercial energy products in Pakistan are administered by the government. According to the *Government Sponsored Corporations* (GOP, 1985a):

"Active state intervention in the allocation of economic resources is justified by its protagonists on both grounds of efficiency and equity. It is argued that the efficiency of free market forces, which are generated by the pursuit of private interests, is limited by the extent to which private and social interests coincide. Certain economic activities, by their very nature, are characterised by a substantial divergence between private and social interests, commonly described in economic literature as 'externalities'. State intervention in these activities is, therefore, necessary to allow for these external costs and benefits and thereby achieve greater economic efficiency. The equity argument is based on the assumed obligation of the state to assure a certain minimum level of basic consumption for all sections of society. State intervention in critical sectors such as food and petroleum products is therefore necessary to assure stable prices and adequate *per capita* production and consumption."

Thus the stability of prices and satisfaction of basic needs of all sections of society are two motives behind regulation of prices of certain commodities (including energy products). According to this report the pricing formulas for products such as petroleum products and natural gas are established by consultation between the corporations concerned and their controlling Ministries. However, there is no policy document precisely stating these formulas and the objectives or motives behind price setting of each such

product. The objectives of a rational and equitable energy pricing policy have been generally put as (Bahatia, 1984; Munasinghe, 1985, de Lucia and Lesser, 1985, Webb, 1978):

- (i) promoting economically efficient allocation of resources both within the energy sector and between it and rest of the economy;
- (ii) enabling the utilities to generate sufficient surplus funds to finance their future investment requirements;
- (iii) reflecting the costs of energy supplies to different categories of customers in the corresponding consumer prices;
- (iv) inducing the most efficient utilisation of available energy resources;
- (v) providing a certain minimum level of energy to all citizens at prices affordable by the poorest;
- (vi) encouraging inter-fuel substitutions to achieve desired objectives such as conservation of certain fuels.

In this chapter we examine energy pricing in Pakistan to infer the relative weights placed on these different objectives. In our analysis we examine the historical growth rates of regulated energy prices during 1971-1988 and calculate sales and import taxes (subsidies) on these products for the base year of this study.

Our analysis encompasses the administered energy prices for three major commercial energy products: petroleum products, natural gas, and electricity. The six major petroleum products that have regulated prices are:

- (i) kerosene,
- (ii) high speed diesel,
- (iii) light diesel oil,
- (iv) gasoline,
- (v) furnace oil, and
- (vi) aviation fuel.

Our analysis is confined to the first five petroleum products due to lack of data on price of aviation fuel.

The government discriminates between various types of consumer in setting prices for natural gas and electricity. Natural gas prices differ between the household, manufacturing and services sectors. Similarly, electricity prices are also different for the household, manufacturing, agriculture and services sectors. Thus we examine altogether twelve energy prices: five prices for petroleum products, four electricity prices, and three natural gas prices.

In Section 2.2 we analyse growth rates in regulated energy prices for the period between 1971-72 and 1987-88. In Section 2.3 we describe the pricing mechanism of the administered energy prices and compute the implicit and explicit *ad valorem* sales tax (subsidy) rates on energy products. The computation of the explicit and implicit taxes on energy prices in this section underlies hypothetical reforms in energy pricing simulated later in this study.

2.2 Historical Growth Rates of Energy Prices (1971-1988)

In this section we examine the growth rates of energy prices between 1971 and 1988. First, we analyse of the average growth rates in nominal prices of petroleum products, electricity and natural gas. We then analyse the growth rates of these prices in real terms. As mentioned, there is user-discrimination in the prices of electricity and natural gas. We analyse the growth rates of real energy prices for major consumers.

Table 2.1 compares the energy price trend between 1971-72 and 1987-88. As shown in Table 2.1, petroleum product prices grew by 12 to 14 per cent *per annum* in that period. Among petroleum products, furnace oil experienced the highest increase in nominal price, at 14 per cent *per annum*. The prices of kerosene and light diesel oil increased at an average rate of 13 per cent *per annum*. The major increases in petroleum product prices occurred in the 1970s when world oil prices increased rapidly; these prices grew little during the 1980s.

Table 2.1 Average Growth Rates of Energy Prices in Pakistan (1971-1988)

Energy Products, CPI & GDP deflator	Average Growth Rate (per cent <i>per annum</i>)
<i>Petroleum Products</i>	
Kerosene	13.0
High speed diesel	12.0
Light diesel oil	13.0
Gasoline	12.0
Furnace oil	14.0
<i>Electricity</i>	
Electricity for households	5.0
Electricity for agriculture	8.0
Electricity for manufacturing	11.0
Electricity for services	12.0
<i>Natural Gas</i>	
Natural gas for households	9.0
Natural gas for manufacturing†	17.0
Natural gas for services	14.0
CPI	10.4
GDP deflator	10.1

† Excluding cement, fertiliser and electricity industries.
Source: GOP (1989), WAPDA (1989).

Compared to fairly even price increases for petroleum products, the average increase in the price of electricity ranged between 5 and 12 per cent *per annum* depending on the user. The sectors carrying the biggest electricity price increases were services (12 per cent *per annum*) and manufacturing (11 per cent *per annum*). Households enjoyed the lowest price increases: 5 per cent *per annum*, only half of the growth rate in the CPI and less than half of the growth rates in electricity prices for the manufacturing and services sectors. The second-lowest growth was in the electricity price for agriculture; about 3 to 4 percentage points lower than the growth in electricity prices for manufacturing

and services sectors. Hence we observe (see Table 2.1) large differences in the growth rates of electricity prices for different consumer categories.

There are similar deviations in the growth rates of natural gas prices. They grew in the range of 9 to 17 per cent *per annum* during 1971-72 to 1987-88. As shown in Table 2.1, the highest growth rate was in the price for the manufacturing sector (17 per cent). The price for the services sector grew by 14 per cent *per annum* compared to the price for households which grew by only 9 per cent *per annum*.

Between 1971-72 and 1987-88, the CPI and GDP deflator increased at about 10 per cent *per annum*, which was lower than the growth rates of most energy prices. Hence, all energy prices increased in real terms except for natural gas and electricity prices to households, and electricity prices to the agricultural sector.

Table 2.2 shows the major users of each petroleum product. Among petroleum products, furnace oil is mainly consumed in the manufacturing sector and kerosene by households. The major consumer of high speed diesel is the transport industry while gasoline is mainly used by households and the services sector for private transport. Light diesel oil is mainly used in the agricultural sector for underground water pumping and in some small-scale manufacturing industries.

Table 2.2 Major Users of Petroleum Products

Petroleum Product	Major User
Kerosene	Household sector
High speed diesel	Transport sector
Light diesel oil	Agriculture sector
Gasoline	Household sector (for private transport)
Furnace oil	Manufacturing sector (including electricity industries)

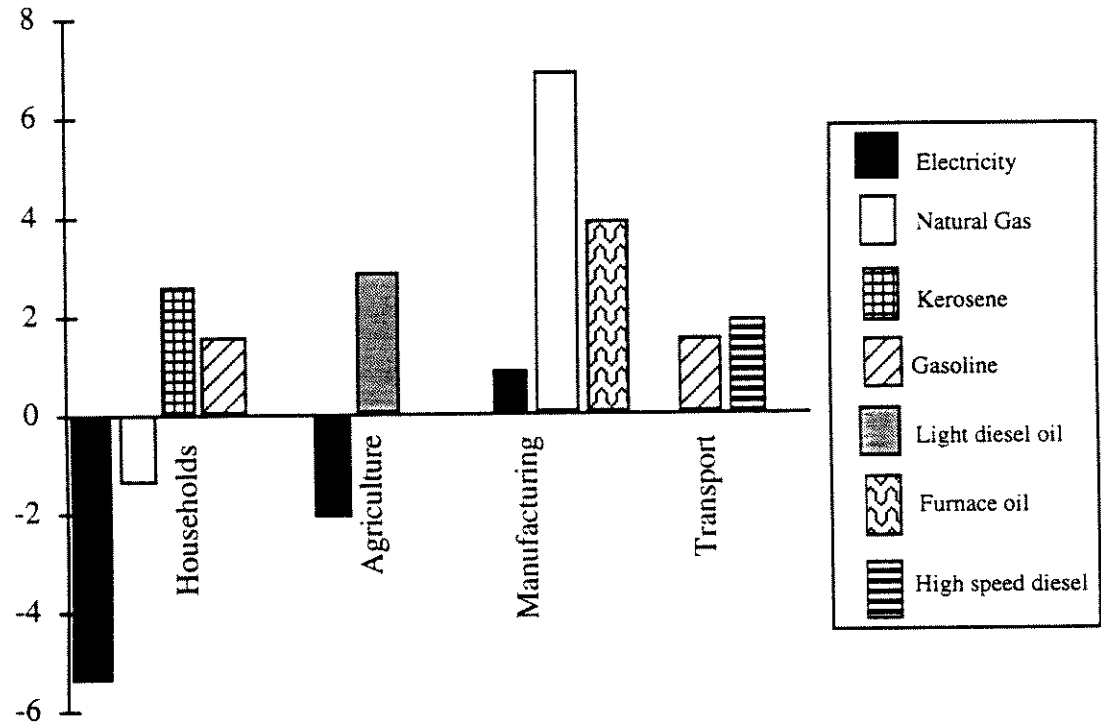
Source: Khan (1986), GOP (1989).

Figure 2.1 shows the *per annum* growth rates of real prices of energy

between 1971-72 and 1987-88 for the four major user groups. During this period real prices of electricity for households declined sharply and there was a small decline in real prices of natural gas for them. Kerosene prices to households increased in real terms.

For the agricultural sector, there was a decline in the real price of electricity but a small increase in real price of diesel.

Figure 2.1 Growth Rates in Real Energy Prices 1971-1988
(per cent *per Annum*)



Source: Based on Table 2.1

All real energy prices for the manufacturing sector increased. The prices of furnace oil (14 per cent *per annum*), electricity and natural gas (11 and 17 per cent respectively) grew rapidly compared to the increase in the GDP deflator (10 per cent *per annum*). It is noteworthy that the real price of natural gas to the manufacturing sector increased more rapidly than that of furnace oil. In the 1970s the growth rate in the real price of natural gas to the manufacturing sector was zero. The real price of furnace oil, however, grew rapidly in line with the rapid increase in world oil prices. Administered natural gas prices were held down to protect manufacturers from this rapid increase in energy costs. As

world oil prices declined during the 1980s, the price of natural gas was increased rapidly by the government. During the 1970s the average annual growth rate of natural gas price to manufacturing was about 13 per cent, This was increased to 23 per cent during the 1980s. On the other hand, the average growth rate of furnace oil price declined from 20 per cent during the 1970's to about 7 per cent during the 1980s.

Prices of both high speed diesel and gasoline, used in public and private transport, increased at 12 per cent *per annum* compared to a 10 per cent growth in the CPI.

Energy prices have undergone considerable changes during 1971-1988. These changes were partly induced by changes in world oil prices and partly by government. For example, rapid growth rates in petroleum product prices during the 1970s were the result of increases in world oil prices. During the oil crisis period, the manufacturing sector was encouraged to use natural gas in place of furnace oil. In line with this objective, administered natural gas prices to the manufacturing sector remained constant in real terms during the 1970s. This trend was reversed during the 1980s when the real gas prices were increased rapidly.

Summary

Our analysis of energy prices during 1970-1988 shows that:

- (1) real electricity prices declined for households and agriculture, and increased marginally for manufacturing during this period;
- (2) real price of natural gas declined for households and increased significantly for manufacturing; and
- (3) over the same period, petroleum product prices increased more rapidly for the manufacturing sector and households than for the transport and agricultural sectors.

Thus, in general, households experienced slower growth in energy prices than did all other sectors.

2.3 Implicit and Explicit Taxes on Energy Products in 1983-84

In this section we compute the implicit and explicit tax rates on the major energy sources: petroleum products, natural gas, and electricity, and discuss the differences between these tax rates.

2.3.1 Taxes on Petroleum Products

In Pakistan, both public and private companies are involved in refining crude oil and marketing petroleum products. These companies work under the direct supervision of the government. The government regulates their profit margins and sets prices of petroleum products at the various stages. Hence it is impossible to measure effective taxes (or subsidies) by looking at the explicit taxes on petroleum products. In this section we compute the magnitude of taxes on petroleum products in 1983-84. We also discuss some explicit taxes on these products.

The regulated prices of petroleum products in Pakistan have the following components:

- (i) ex-refinery price,
- (ii) excise/custom duty,
- (iii) trade margins,
- (iv) transport margin, and
- (v) development surcharge.

Table 2.3 gives the petroleum products price structure in 1983-84 showing these components.

Table 2.3 Petroleum Products Price Structure in 1983-84
(Rs / Litre)

Petroleum Products	Ex-Refinery Price 1	Customs /Excise Duty 2	Distribution Margin 3	Dealer Commission 4	Prescribed Price 1+2+3+4 5	Inland Freight Margin 6	Development Surcharge 8-5-6 8	Fixed Sale Price 8
Kerosene	2.44	0.00	0.05	0.00	2.49	0.24	0.02	2.75
High speed diesel	2.97	0.25	0.03	0.03	3.29	0.28	0.43	4.00
Light diesel oil	2.41	0.04	0.04	0.00	2.49	0.21	0.05	2.75
Gasoline	4.64	0.88	0.07	0.05	5.66	0.29	0.05	6.0
Furnace oil†	1355.0	35.2	16.8	0.0	1407.1	308.3	4.6	1720.0

† Rs per metric tonne.

Source: GOP (1989).

The ex-refinery prices are the prices at which the refinery industry sells its products to the marketing companies. The excise and custom duties are sales¹ taxes levied at the same rate on domestically produced and imported petroleum products. The government fixes the ex-refinery price, tax rates, trade margins and transport margin on all petroleum products along with their retail prices. The sum of the ex-refinery price, taxes and the two trade margins is called the prescribed price. The difference between the fixed retail price of a petroleum product and the costs of supply (prescribed price plus transport margin) is the development surcharge which is paid by the marketing companies. The government uses the development surcharge as an instrument to stabilise prices of petroleum products. Fluctuations in any component of the

¹ Throughout this thesis, we have divided all indirect commodity taxes into two types: import tax and sales tax. Import tax is levied on imports of a commodity. Sales tax is levied on sale of a commodity irrespective of source of supply. Sales tax is paid by both imported and domestically produced commodities while import tax is paid by imports only. See section 5.39 and 5.3.10 in Chapter 5 for further details.

regulated petroleum products prices are offset by changes in the development surcharge without affecting the fixed retail price. The development surcharge is an implicit tax and its rate changes with changes in the costs of production, distribution and transportation.

No data is available on the marginal cost of petroleum products or the criteria for setting their ex-refinery prices. According to a report on the government sponsored corporations (GOP, 1985a), the ex-refinery prices of petroleum products are determined on the basis of an overall 18 per cent rate of return on paid up capital in the refinery sector. However, no criteria or formula on setting of price of each product is given in the report. Hence, we cannot compute the difference between the actual marginal cost of production and the set ex-refinery price of each petroleum product.

From the structure of petroleum product prices given in Table 2.4, we compute two types of *ad valorem* tax rates on the five petroleum products as follows.

- (i) Source-discriminating tax rates which are levied only on imports of a commodity. We refer to them as import tax (subsidy) rates from now on (see Section 5.3.10 for further clarification).
- (ii) Product-discriminating tax rates which are levied on a commodity on both imported and domestic good at the same rate. We refer to these taxes as sales tax rates from now on.

Import Tax on Petroleum Products

The tax rates on petroleum products given in the *Energy Year Book* (GOP, 1989) are uniformly levied on both imported and domestic products. Thus, there are no explicit import taxes on these products, however, there are some implicit taxes on them. Here, we discuss the estimation procedure of these implicit import tax rates. The implicit import tax (subsidy) on a petroleum product is the difference between its fixed ex-refinery price and its border price. The border price is the cost, insurance and freight (CIF) value of imports in domestic currency. The average import costs of petroleum products in 1983-84,

given in US dollars, are converted to domestic currency prices at the official exchange rate of 1983-84. Columns 1 and 2 in Table 2.4 report these values for five petroleum products while column 3 shows our estimated *ad valorem* rates in 1983-84 on these petroleum products.

Table 2.4 Implicit *Ad Valorem* Import Tax Rates on Petroleum Products in Pakistan (1983-84)

Petroleum Product	Ex-Refinery Price Rs /Litre	CIF Rs /Litre	<i>Ad Valorem</i> Import Tax Rate (per cent)
Kerosene	2.44	2.95	-17.0
High speed diesel	2.97	2.80	6.0
Gasoline	4.64	2.98	56.0
Furnace oil [†]	1355.00	2494.00	-64.0

[†] Rs per metric tonne.

Source: GOP (1989).

Table 2.4 shows that two of the imported petroleum products had tax while the other two petroleum products had subsidies. Gasoline, which is mainly used in private transport, had the highest import tax rate of 56 per cent while high speed diesel, the fuel used in public transport, had a 6 per cent import tax. There was an implicit import subsidy on kerosene of 17 per cent and a subsidy on imports of furnace oil of about 64 per cent. Hence there were source-discriminating taxes on petroleum products.

Product-discriminating Taxes on Petroleum Products

In this section we compute the product-discriminating taxes on petroleum products. There are three cost-components of purchaser price of a petroleum product: production costs, *i.e* ex-refinery price; trade margins and inland transport cost (see Table 6.3). These components are set by the government along with the purchaser price of a petroleum product. In this section we first estimate the actual values of these components which are reported in column 1 to column 3 of Table 2.5. The sum of these three cost-components gives us the actual supply cost of a product. The difference

between the actual cost and the fixed purchaser price of a product is the tax on it. In the next few paragraphs we discuss the estimation procedure of the three cost-components for five petroleum products. We then discuss the differences in the sales tax rates on these products which are reported in column 6.

Since we do not have any data on marginal costs of each petroleum product, we assume that their ex-refinery prices are their actual production cost. As shown in column 3 and 4 of Table 2.3, the trade margin set by the government are not uniform for the five products and we also do not have data on the actual trade margins on these products. Therefore we compute an average of the trade margins set for five products and assume it as the actual trade margin cost for all the five products which is reported in column 2 of Table 2.5².

Table 2.5 *Ad Valorem* Sales Tax Rates on Petroleum Products in 1983-84

	(1)	(2)	(3)	(4)	(5)	(6)
		Estim	Inland	=	Fixed	Power of
	Ex-	ated	Freight	(1) +(2)	Sale	<i>Ad</i>
	refinery	Trade	Margin	+ (3)	Price	<i>Valorem</i>
Petroleum Product	Price	Margins		Actual		Sales Tax
	Rs /Litre	Rs /Litre	Rs /Litre	Cost	Rs /Litre	Rate
Kerosene	2.44	0.06	0.28	2.78	2.75	0.99
High speed diesel	2.97	0.06	0.33	3.36	4.00	1.19
Light diesel oil	2.41	0.06	0.31	2.78	2.75	0.99
Gasoline	4.64	0.06	0.17	4.87	6.00	1.23
Furnace oil [†]	1355.00	63.90	346.75	1765.65	1720.0	0.97

[†]Rs per metric tonne.

Source: GOP (1989).

Until 1991 the inland transport margin on each petroleum product was set by the government. The marketing companies were compensated for the

² We convert the set trade margin on furnace oil from Rs. per tonne to Rs. litre to add it up to other four trade margin costs. Later on we compute the Rs. per tonne rate using the average rate.

difference between the actual transport cost of petroleum products incurred and the prescribed rate set by the government. Kuijper (1982) has given actual transport cost for petroleum products in 1978-79 in her study on petroleum product prices in Pakistan. Since actual transport cost data are not available for 1983-84, we inflate the 1978-79 transport costs by the growth rate of the GDP deflator to estimate the 1983-84 transport costs for petroleum products. Column 3 in Table 2.5 reports our estimated transport cost values.

Comparison of columns 4 and 5 shows that the set purchasers' prices for kerosene, light diesel oil and furnace oil are lower than the cost of supply. For the other products, the opposite is the case. Column 6 shows that subsidies on three products are between 1 and 3 per cent and sales taxes on two products are 19 and 23 per cent. This pattern of taxes is very similar to the pattern of source-discriminating taxes except in two respects. First the subsidy rates of sales taxes are much smaller relative that for source-discriminating taxes. Second, the difference in tax rates on high speed diesel and gasoline is smaller for sales taxes compared to wide difference in their source-discriminating taxes.

Summary

In Table 2.6 we report the *ad valorem* import tax and explicit sales tax rates on petroleum products in 1983-84. The table shows that there were source- and commodity-discriminating taxes on petroleum products.

Table 2.6 *Ad Valorem* Tax Rates on Petroleum Products in 1983-84

Petroleum Product	<i>Ad Valorem</i> Import Tax Rate (per cent) (1)	<i>Ad Valorem</i> Sales Tax Rate [†] (per cent) (2)
Kerosene	-17.0	-1.0
High speed diesel	6.0	19.0
Light diesel oil	0.0	-1.0
Gasoline	56.0	23.0
Furnace oil	-54.0	-3.0

† These tax rates are levied on both imported and domestically produced petroleum products.

Source: GOP (1989).

The tax structure described in Table 2.6, suggests objectives of the administered pricing policy for petroleum products in Pakistan as follows:

- Since kerosene is a fuel for low-income urban households and a fuel for lighting for non-electrified rural households, the subsidy on it is given to balance out the inequalities in the income distribution.
- Since furnace oil is used mainly in the manufacturing sector, its price is kept at the minimum possible level to boost the manufacturing activities.
- High speed diesel is used for public transport and in the agricultural sector, so tax rate on it is lower than gasoline which is used for private transport.

The import prices of petroleum products were higher till 1983-84, this import tax structure suggests that gasoline and high speed diesel are highly taxed to subsidise kerosene and furnace oil during periods of high oil import

prices. The structure of the types of taxes shows that these two products are used to generate indirect tax revenue. In 1983-84, the share of indirect tax revenue from petroleum products was about 13 per cent in total indirect tax revenues. We also notice that the sales tax rates on these two products are not much different while there is a big difference between the import tax rates on these products. An other motivation behind discriminating tax rates could be the management of the trade balance. Gasoline is mainly used in private transport by the higher income groups. The high tax on it suggests that price setting is motivated by income distributional considerations.

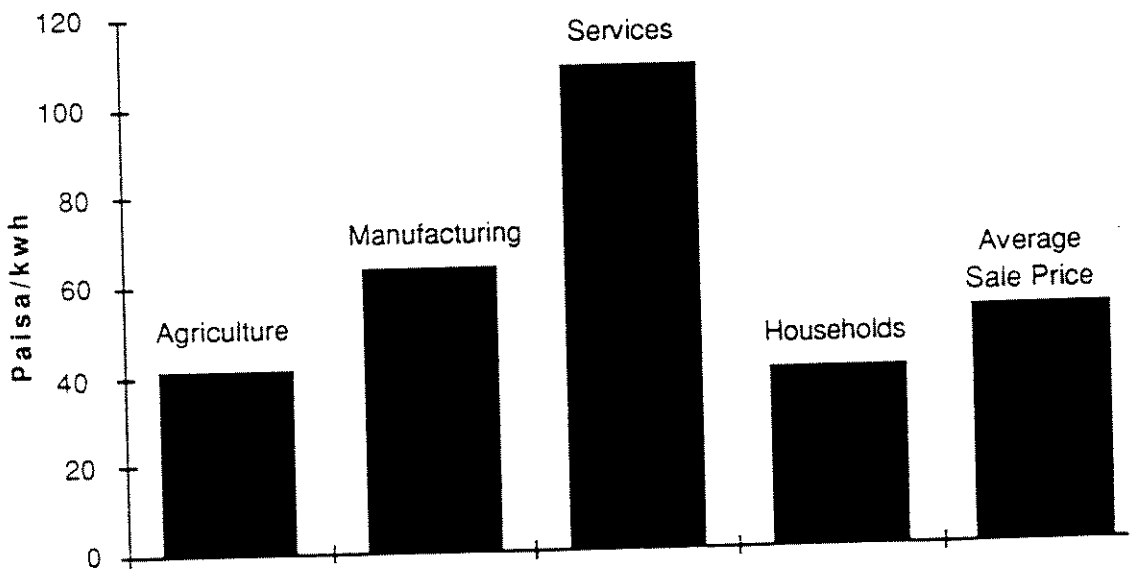
2.3.2 Taxes and Subsidies on Electricity Prices by Consumer Category

In this section we compute the magnitude of the implicit tax (subsidy) rates on electricity sales to four major consumer categories and discuss the differences between these rates. In Pakistan, responsibility for the generation, transmission and distribution of electricity lies with two organisations: namely, the Water and Power Development Authority (WAPDA), a fully government-owned corporation; and the Karachi Electric Supply Corporation (KESC), a public-limited company which works under the management control of WAPDA. Electricity prices for different categories of consumers are fixed by the government to allow the electricity utilities a reasonable net return on their capital after meeting operating costs and allowing for depreciation of assets, interest charges and taxes (see GOP, 1985a and WAPDA, 1986).

All investment funds come either from the public budget or from the revenues generated by the electricity sector. A new electricity pricing criterion was introduced in the 1980s (WAPDA, 1986) due to growing demand for investment funds in the electricity sector and on advice from international loan giving agencies such as the World Bank and the International Monetary Fund (IMF). This requires that electricity prices should be set to generate sufficient revenues to finance 40 per cent of the tri-annual investment requirement of electricity sector. However, up till now electricity tariffs have not been fully adjusted to meet the 40 per cent investment criterion.

Figure 2.2 shows the average sale prices of electricity in 1983-84 for four consumer categories. Households and the agricultural sector paid less than the manufacturing and services sectors. Do these differences in the average sale price of electricity imply that the agricultural and the household sectors are being cross subsidised by the manufacturing and the services sectors?

Figure 2.2 Average Sale Price of Electricity by Consumer Categories in 1983-84



Source: WAPDA (1989).

According to the most recent study made by the WAPDA (1986) on the restructuring of electricity tariffs, the net-operating surplus in 1984-85 was 6.24 per cent of capital. In the study, the rates of net-operating surplus were computed for all the consumer categories. These rates were computed using the incurred average cost of electricity sales to these categories and revenues generated on these sales. According to the study, these rates of return varied by major consumer categories between -5.04 per cent to 23.22 per cent. Thus the prices of electricity for different consumer categories were not proportional to the cost of supplying electricity to these consumers. The rates of net-operating surplus on electricity sales to the household and the agricultural sectors were -5.4 and 1.25 per cent respectively. For other consumers, this rate was 15 per cent on the sales to the small-scale industries compared to the highest rate of 19 per cent on electricity sales to the large-scale industries.

As mentioned, the electricity sector, on aggregate, earned a 6.24 per cent rate of net-operating surplus in 1984-85 on its capital (WAPDA, 1986). However, these rates were not uniform across consumer categories. In this section we compute *ad valorem* tax rates on electricity sales to the five major consumer categories by assuming a uniform rate of net-operating surplus for all categories. The study on restructuring of electricity prices (WAPDA, 1986) gives the required revenues by consumer categories that ensures a uniform 6.24 per cent rate of net-operating surplus on electricity sales to all consumers³. We compute the implicit tax rate on electricity sales to each consumer category using the required revenues and the actual revenues reported in columns 1 and 2 of Table 2.7. Column 3 in Table 2.7 gives our computed *ad valorem* tax rate on electricity.

Table 2.7 Implicit *Ad Valorem* Tax Rates on Electricity by Major Consumer Categories in 1984-85

Consumer Category	Actual Revenues Collected Million Rupees 1	Revenues Required for Uniform Rate of Return Million Rupees 2	<i>Ad Valorem</i> Tax Rate (per cent) 3 = (1 - 2 ÷ 2)
Household	1578.0	2768.0	-43.0
Manufacturing sector	2121.0	1454.0	46.0
Manufacturing sector [†]	853.0	535.0	59.0
Manufacturing sector ^{††}	1268.0	919.0	38.0
Agriculture sector	1401.0	1836.0	-24.0
Services sector	965.0	662.0	46.0

[†] Large -scale industries. ^{††} Small-scale Industries only.

Source: WAPDA (1986), WAPDA (1989).

The computed implicit *ad valorem* tax rates given in Table 2.7 show that

³ The report contains various categories of electricity sales to the manufacturing industries. We have chosen two representative categories for them.

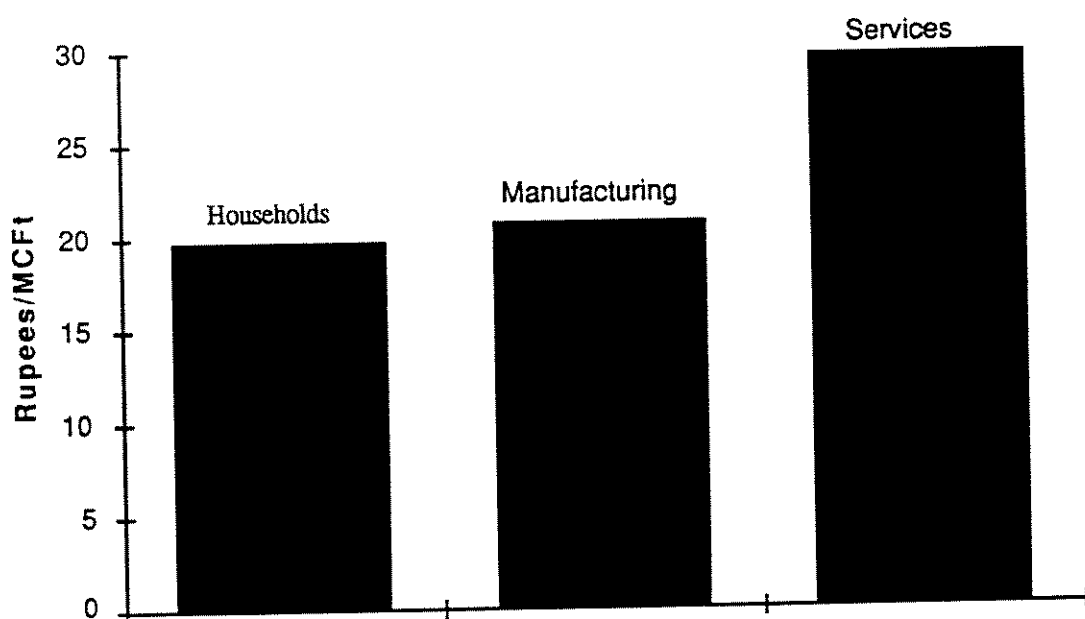
there were subsidies on electricity sales to the households and the agriculture sector in 1984-85. In contrast, there were high implicit tax rates on electricity sales to the manufacturing and the services sectors. It shows that there is a user discrimination in these implicit taxes on electricity sales. The discrimination in favour of households and the agriculture sector in this tax structure is similar to that observed in the tax structure of petroleum products. Since electricity tariff in 1983-84 was very similar to the electricity tariff in 1984-85, we assume that the implicit tax rates were same in the two years.

2.3.3 Implicit Taxes on Natural Gas Prices

In Pakistan the extraction, production, transmission and distribution of natural gas are handled by separate government sponsored corporations subject to government regulated prices. According to a report on the government sponsored corporations, the basic price at each level (extraction, production, transmission, and distribution) is regulated in a manner that enables these corporations to fulfil certain financial covenants of the government's guaranteed loans from multi-lateral credit institutions (GOP, 1985a). There is an indirect tax on extraction of raw natural gas but there are no explicit taxes on production and marketing of natural gas. Unfortunately no data is available on the cost of natural gas supply to different consumer groups. However, we observe that the regulated prices of natural gas sales to three consumer categories are not uniform.

Figure 2.3 shows natural gas sales price by consumer categories in 1983-84. The price of natural gas for the manufacturing sector (excluding cement and fertiliser industries) was about 3 per cent above the price for households and was about 44 per cent below the price for the services sector.

Figure 2.3 Average Sales Price of Natural Gas by Consumer Categories
1983-84



Source: GOP (1989).

No published data are available on the marginal cost of natural gas sales to different consumer categories. Therefore, we calculate the *ad valorem* tax rates on natural gas sales to major consumer categories using the weighted average of purchasers' prices of natural gas for these categories as the basic price. In Table 2.8, column 1 shows the average purchaser price of natural gas for four major consumer categories while column 2 contains the *ad valorem* sales tax rates. According to our calculation, the weighted-average purchaser price of natural gas was Rs 18.34 per MMCFT in 1983-84.

The *ad valorem* sales tax rates reported in Table 2.8 are calculated using Rs 18.34 per MMCFT as the basic price of natural gas. According to our calculations, there was a subsidy of about 23 per cent on natural gas sales to the electricity industry, while there was a high sales tax on natural gas sales to the services sector. The tax rate on natural gas sales to households was lower than the rates levied on sales to the manufacturing and services sectors.

Table 2.8 *Ad Valorem* Tax Rates on Natural Gas Sales to Major Consumer Categories in 1983-84

	(1)	(2)
Consumer Category	Average Sale Price Rs /MMCFT	<i>Ad Valorem</i> Tax Rate (per cent)
Household	20.0	9.0
Manufacturing [†]	20.63	12.0
Services	29.63	62.0
Electricity ^{††}	14.20 [†]	-23.0

[†] Excluding electricity industries.

^{††} calculated from data given in WAPDA (1986).

Source: GOP (1989), WAPDA (1989).

2.4 Conclusion

The average growth rates of energy prices between 1971-72 and 1987-88 showed that all energy prices grew in real terms except the prices of natural gas and electricity for households, and of electricity for the agricultural sector. The prices faced by the manufacturing and transport sectors in general have been increasing in real terms; especially for natural gas and petroleum products.

There are some implicit taxes on these energy products besides some explicit taxes due to the administered energy prices. We have calculated the tax rates that incorporate all implicit and explicit taxes on energy products. Analysis of these tax rates helps us to infer the underlying objectives of regulated energy prices in Pakistan. The basic features of regulated energy pricing in Pakistan that emerge from our analysis can be summarised as follows.

- (i) Administered energy prices in 1983-84 had high implicit taxes on some of the energy products and subsidies on others. The weighted-average tax rates show that there was no import tax on petroleum products while there was an about 13 per cent sales tax on petroleum products on aggregate.
- (ii) The household sector consistently either receives subsidies or pays the lowest tax rates for energy products.
- (iii) Energy product sales to the agricultural sector have relatively lower taxes compared to the tax rates levied on the manufacturing sector and the

services sector.

- (iv) The rates of return on capital in the refining and natural gas industries are regulated by the government. The implicit tax rates on petroleum products and natural gas are adjusted to ensure the guaranteed rate of returns in these industries.
- (v) For electricity prices, the gap between the cost of supply and the regulated price affects the rate of return on capital in the electricity sector.

There are four major motives that can be inferred from our analysis in this chapter: promotion of equity, stability of energy prices, management of the balance of trade and generation of indirect tax revenue. The first two inferred objectives are in line with the announced motives of the government in regulation of prices (GOP, 1985a). Under the first objective, energy prices charged to the household sector are kept low to make energy affordable for the poorest section of society. Thus energy is considered a necessity and its price is used to counter-balance the large disparities in incomes. Under the second objective, energy prices are fixed by the government and any change in the cost of energy supply affects either the implicit tax rate or the rate of return on capital in the sector supplying energy products. Under the third objective, there is higher source-discriminating tax on gasoline to discourage imports. To meet the two conflicting objectives of equity promotion and revenue generation, there are user-, product- and source-discriminating taxes on energy products. In this chapter, we achieved our second task, *i.e.*, estimation of distortions in energy prices in various forms of taxes, and inference of motives behind them.

Chapter 3

A Review of Energy Pricing Studies

3.1 Introduction

The 1970's oil crisis stimulated research into modelling of energy policy and planning issues. Several models have been developed to analyse issues in this area in both the developed and developing countries. These models vary in their scope of analysis, objectives, analytical techniques, theoretical framework and time horizon. As pointed out by Blitzer (1986), no single model can be developed for practical use that addresses all the issues in an area. Therefore, models have been developed to focus on certain issues depending on the severity of the problem faced by the countries.

The focus of energy models developed for Pakistan has mainly been on forecasting energy demand and planning least-cost energy supply to satisfy the projected demand. For energy demand forecasting, ENER Petro Tech (1979) and Riaz (1984) have developed econometric models, while IEDC (1983) and Khan (1986) have formulated engineering-simulation models. In these models, medium- to long-term energy demand forecasts have been made for different scenarios of economic development. In the latter type of models the underlying assumption is that energy demand is stimulated by the pace of economic growth along with changes in production technology. In addition, the trend for households to substitute traditional energy by commercial energy are considered, to determine commercial energy demand for each fuel type. In these models the role of energy pricing is completely ignored. In the econometric models, income and price elasticities of energy demand are estimated using time-series data over 20 years. The model was used to forecast energy demand assuming for scenarios of future economic growth. In formulating the scenario, steady growth in energy prices has is assumed — implying a

continuation of present energy pricing policies.

The objective of this chapter is to review some of the energy pricing studies for Pakistan which used a non-partial equilibrium framework. We divide this review into two parts. The first part covers the studies of Pakistan while the second part reviews the studies of other developing countries. Three studies have analysed energy pricing issues for Pakistan: Chern (1987); ENERPLAN (1988); Jalal (1988). In Subsections 3.2.1 to 3.2.3 we review these three studies. In Subsection 3.3 we give a summary of some energy management models for developing countries with reference to energy pricing issues and the modelling of energy industries.

3.2 Studies on Energy Pricing for Pakistan

Chern (1987) developed a macro-econometric model of Pakistan to compute the economic effects of increases in world oil prices between 1973 and 1983. The objective of the ENERPLAN (1988) study is to evaluate the impacts of changes in energy prices in Pakistan on prices of non-energy commodities. The analysis was carried out using an input-output model. Jalal's study (1988) analyses the long-term impacts of alternative energy pricing policies using a CGE model. The following paragraphs discuss the main features of these three studies and summarise their main findings.

3.2.1 The Pricing Impact of Changing Energy Prices

ENERPLAN (1988) carried out a study to forecast the impact of increasing electricity prices on prices of non-energy goods for the period 1986-2000. In the study the real prices of electricity are assumed to grow according to a proposed schedule. These proposed electricity prices are required to support the least-cost development plan for the electricity sector over the period 1987-2010 (UNDP/World Bank, 1987).

An input-output model was developed in which the price of the output of a sector is determined by the cost of produced and non-produced inputs involved in its production. The model identifies 11 non-produced inputs including capital, labour, land, foreign exchange, taxes or subsidies, profit margins, and four energy products

(coal, oil, natural gas, electricity). The prices of non-produced inputs are assumed exogenous to the system. For 83 sectors, the price of each commodity is defined as the weighted sum of prices of produced and non-produced inputs. Input quantities per unit of output are used as the weights. The model allows substitution between the four energy products.

The model uses the 1981 input-output table of 83 sectors developed for Pakistan at Warwick University. Two alternative cases have been considered to compute the effects of increases in electricity prices. In the first case, coefficients of energy inputs are assumed to remain constant over time, while in the alternative case these coefficients have been assumed to change in response to changes in relative energy prices and to changes in production technology.

The model estimates increases in commodity prices by sector until the year 2000, starting from 1981, the base year of the study. According to the price scenario, the price of electricity grows in real terms at an average of 9.4 per cent *per annum* over the period of 1986 to 1991, and at an average rate of 4.0 per cent *per annum* for the period 1991 to 2000. The results show that price increases induced by increasing electricity prices are very small for many sectors of the economy. Output prices of 40 sectors (out of the 83 sectors) increase by less than 0.5 per cent *per annum* over each of the periods (1986-1991 and 1991-2000). This is despite of a 57 per cent increase in electricity price in the first period and a 43 per cent increase in the second period. Output prices of only 20 sectors increase more than 1.0 to 1.5 per cent for both periods. The three sectors with the largest price impact, in descending order of importance, are 'rice milling'; 'cement'; and 'grain milling'. For these sectors, price increases are 6.3, 4.0 and 3.0 per cent respectively over the period 1986-1991.

The aim of the ENERPLAN study was to evaluate the pricing impacts of changes in energy prices. However, the study effectively estimated only the initial increase in production costs of commodities when electricity prices are increased. Since prices are affected by both cost-push and demand-pull factors, changes in both costs and demand need to be considered in a simultaneous framework to determine the price implications of changes in electricity and other energy prices. The model

does not incorporate any demand or supply functions for commodities and therefore does not allow changes in production costs to affect the demand for and supply of a commodity. What are the effects on the demand and supply of commodities and on their prices (consequent to these changes) are not computed by the model.

For example, the simulation results of the study show a significant increase in the production costs of 'rice milling', 'cement' and 'grain milling' industries. Rice is one of the major exports of Pakistan; cement is one of the major inputs to capital formation and flour (output of grain milling industry) is a staple food. Since the model does not incorporate an export demand function, the effect on the export demand for rice and its production is not computed by the model.

Similarly, the model does not consider the effects on real consumption of households when there is a 57 per cent increase in the price of electricity in real terms along with an increase in the prices of all other commodities including the staple. Consequently the effects on the demand for commodities due to the change in households' real expenditure and relative prices of commodities are also not taken in to account.

The scope of the study is confined even if we assume that all feed-back effects of changes in electricity prices are small and negligible.

- First, the effect of increasing electricity price on domestic prices is one of its many effects. The scope of the study is limited as it does not address the effect on real GDP, exports, indirect tax revenues, *etc.*
- Second, the study also touches only one of the issues of electricity pricing, *i.e.*, raising its level. In electricity pricing policy, a more important issue is the removing of user-discriminating taxes. The ENERPLAN model does not have the capability to address this issue.
- The model estimates the impact of rising electricity prices on the cost of production in isolation from its impact on electricity demand. Will electricity demand keep on increasing with rapidly increasing electricity prices? Reduced demand may affect the required increase in electricity prices.

3.2.2 Macro economic Impacts of Oil Shocks in Pakistan

Chern (1987) has developed a macro-econometric model to simulate the impacts of the two oil shocks on Pakistan's economy. Using the time-series data from 1960-82, the energy-economy relationship was estimated and was used to analyse the effects of the oil crises of 1973 and 1980 on Pakistan's economy. The model was also used to forecast future energy demand, real GDP, inflation, the balance of trade, and other macro variables for alternative scenarios of growth in capital stock, energy and export prices.

The model consists of seven structural equations which determine energy demand (*per capita* and aggregate), real GDP, energy imports, inflation indicated by wholesale price index (WPI), total exports and total imports. There are 19 exogenous variables¹. Real GDP affects energy demand while GDP growth itself is determined by growth in energy and capital. GDP growth interacts with energy imports, total exports, total imports and inflation. The model is described in detail by Chamber (1985).

The model was simulated for the 1973-82 period for two scenarios of world oil price. In the first scenario the energy price is assumed to grow at 19.3 per cent *per annum*. This was the actual growth rate of weighted-average energy prices in nominal terms during this period. In the second scenario, the energy price was assumed to grow at the pre-oil-crisis rate, *i.e.*, 7.2 per cent *per annum* in nominal terms. The study compares effects on six major macro-economic indicators in the two simulation results. The study found that the oil crises had a negative impact on the Pakistan's economy. The study suggested that higher energy prices have the

¹ The exogenous variables are population, weighted-average price of energy, real GDP in the manufacturing, real capital stocks lagged by one year, index of imported energy products, middle-east light petroleum price, total energy production, money supply, index of export prices, ratio of Pakistan's export-prices to the prices in competing developing countries, and seven dummy variables for different years between 1968 and 1980.

following qualitative effects on the economy:

- (1) decrease in total and per capita energy consumption;
- (2) decrease in real GDP growth rate;
- (3) decrease in energy imports and total imports;
- (4) decrease in total exports;
- (5) increase in inflation; and
- (6) increase in the trade deficit.

The comparison shows that if there was no increase in oil prices, then in 1982 real GDP would have been 13 per cent higher, the inflation rate 24 per cent lower, and total energy demand 20 per cent higher. Furthermore, Pakistan would have reduced its trade deficit from about Rs 32 billions in 1982 to only Rs 2 billion; this implies a 94 per cent reduction in the balance of trade.

As pointed out by Chamber (1985, p. 661) in describing the model:

"Although the energy-economy interactions are likely to be more complicated than those represented in this model, we face tremendous constraints by the length of the available data series. The degrees of freedom problem prevent us from expanding the model to include more equations and from including more exogenous variables."

Hence, the scope of the model is limited to estimation of energy-economy interrelationships using aggregated variables. The model has two types of energy price variables: weighted average domestic prices and import prices. Both the prices are given exogenously. Aggregation of all energy prices into one variable does not allow the model to address the various issues of energy pricing such as source-, product- and user-discriminating taxes on energy products.

3.2.3 Jalal's Computable General Equilibrium (CGE) Model for the Evaluation of Energy Pricing Policies in Pakistan

Jalal (1988) developed a CGE model for evaluation of energy pricing policies in Pakistan in the long run. It is a static model based on a neo-classical representation of economic mechanisms. Each economic agent is assumed to maximise his profit or utility, while commodities and factor prices are determined from the general

(Walrasian) economic equilibrium of competitive markets. Basic features of the model are as follows.

- (a) The economy has 13 production sectors producing 17 producer goods. Capital, skilled labour and unskilled labour are viewed as homogenous primary inputs and are assumed to be mobile among sectors. A Constant Elasticity of Substitution (CES) production function which generates value-added from the primary factors. Each production sector combines intermediate inputs and the composite factor (value added) in fixed proportion to minimise cost per unit of output.
- (b) All imports form a single homogenous commodity (foreign exchange) which is produced by exports to the rest of the world, net remittance inflows and foreign borrowing. The last two items are exogenously specified as government endowments of foreign exchange. Foreign exchange produced by exports is represented by a transformation function of traded goods. For production sectors, aggregate imports form a single non competitive intermediate input with a fixed coefficient. For household consumption, there are six consumption items. Among these "food" and "energy" are treated as traded goods and substitution between imported and domestic goods is allowed for these two goods².
- (c) A fixed coefficient transformation function is used to model an investment activity that produces a good named "capital-in-the-future". The product is demanded by the households as well as the government. Total household demand for the "capital-in-the-future" commodity is equal to household savings.
- (d) The demand side of the economy is represented by six consumer groups, distinguished according to their average income and their rural-urban origin. Each household type has different endowments of capital and labour (skilled and unskilled) which determine its income when evaluated at market prices. Each group is assumed to maximise its utility function.

²Other items for current consumption are clothing, housing, transportation and services.

- (e) For each consumer group, there is a two-level nested utility function. On the top level, a CES utility function of present and future consumption is defined. At the bottom level, present consumption is defined by a Cobb-Douglas function of six consumer goods. The demand for each consumer good is derived from maximisation of total present consumption subject to an expenditure constraint. The expenditure constraint is given by the sum of expenditure on six consumer goods being equal to income net of savings. The future consumption is defined as function of present investment. The demands for the present and the future composite goods are derived by maximisation of the utility function subject to an income constraint. The income constraint states that total present consumption plus the present value of future consumption should be equal to total income.
- (f) The government obtains its income by collecting taxes and renting out its capital. It makes transfer payments in the form of subsidies on production and consumption of certain goods. It uses its remaining revenues to buy investment goods.
- (g) A fixed-coefficients transformation function is defined for converting producer goods to foreign exchange. Any trade deficit is assumed to be met by the government endowment of foreign exchange.

Jalal's study focuses on the impacts of alternative energy pricing policies in the long-run. Various hypothetical changes in energy prices are simulated such as a uniform increase in all energy prices, an increase in natural gas price to the import-price level of furnace oil, and increase in the prices of kerosene and diesel to their import-price levels. In all the scenarios, energy prices are increased either individually or cumulatively. In some of the simulation these scenarios are made revenue-neutral by introducing either subsidy on 'food' or reduction in the import tax on imports.

In the analysis of the simulation results, Jalal focuses on two impacts of increasing energy prices: utility indices for six types of households and 'inflationary effects' represented by producer and consumer price indices. The major findings of the study are as follows.

(1) An increase of 10 per cent in all energy prices will result in a 1.2 per cent and 1.0 per cent increase in the producer and consumer price index respectively. There is a small decline in the utility indices of households, while their total energy consumption decreases by 6 per cent. Total primary energy consumption in the economy will decline by 2.5 per cent. The micro and macro economic effects of higher prices and lower energy consumption are not reported for this scenario. This scenario was made revenue-neutral in two alternative simulations. In the first simulation, a 2 per cent subsidy is introduced on 'foods' along with a uniform 10 per cent increase in energy prices. In the second simulation, a reduction of 6.5 per cent in import tax on intermediate inputs (except for petroleum products) is assumed in place of a food subsidy. The result shows that all the negative impacts of higher energy prices are cancelled out. There is a small increase in consumer and producer price indices and an increase in the utility indices of lower-income groups.

(2) For a 50 per cent increase in the natural gas price, there is less than a percentage point increase in the overall producer price index. The utility indices of households, particularly of the low- and middle-income groups, decrease slightly.

(3) A 30 per cent increase in kerosene price has a very small effect (0.5 per cent increase) on the consumer price index. However, there is slightly more decline in the utility index for low-income households compared to the middle- and high-income groups. Again, introduction of a small subsidy on 'food' (0.5 per cent) can make the low income group even better off. Jalal does not discuss the other economic impacts such as GDP, composition of sectoral output or the balance of trade.

(4) The price-scenario of 'elimination of all subsidies from the energy sector' is simulated for 4 cases. In the first case, kerosene and diesel prices are assumed to become comparable to their import prices (an increase of 30.0 and 6.5 per cent respectively) and the price of natural gas is increased by 50 per cent to make it comparable to the import price of furnace oil. The prices of electricity to households and the agricultural sector are increased by 5 and 10 per cent respectively.

The simulation results show that output in all the sectors declines between 0.2 and 7.6 per cent, while utility indices go down by 0.7 to 1.1 per cent. The 'inflationary' effects are small; the producer and consumer price indices go up by 1.83 and 1.51 per cent respectively. However, there are disproportionate changes in the consumer price indices if calculated separately for six consumer groups. The consumer price indices of the low-income and middle-income households show comparatively higher increases.

This price scenario is modified by introducing three alternative changes in taxes and subsidies given on other goods: the energy price increase is coupled with (A) an 8 per cent reduction in import duties, (B) a 2 per cent subsidy on 'food' and (C) a 4 per cent decrease in excise duty. In case (A), the reduction in import duties on intermediate inputs is able to reduce the negative effects of the energy price rise. There is a smaller increase in price indices, and output in some of the sectors increases. In case (B), a subsidy on food offsets the negative effects on household utility, particularly for the low-income group. It decreases the CPI and slightly increases the producer price index. However, there are larger negative effects on the output of all sectors, except for the agricultural sector. In case (c), the reduction in excise duty on the 'food & beverage' commodity has a more favourable effect on the producer price index. The increase in the producer price index, due to higher energy prices, has been reduced by about 50 per cent compared to the base case. The increase in the consumer price index has been cancelled out and utility indices also show favourable changes for the low- and middle-income households. However, except for the agricultural sector and the 'food & beverage' sector, there is a higher reduction in output levels of all other sectors.

Thus, the conclusion of Jalal's study is that elimination of subsidies on energy products will put small 'inflationary' effects but will have negative distributional effects as utility indices for low- and middle-income groups decline more than that of high-income groups. However, an introduction of subsidy on food or a reduction in tax on imports can compensate for this decline in the utilities.

In the following paragraphs, we review this study in the light of energy pricing issues in Pakistan.

As pointed out by Devarajan (1988) that in most of the energy-economy models for developing countries, the international trade theory is missing. This is evident from Jalal's model. In his model, all intermediate imported inputs are represented by a single imported good which is assumed to be complementary. Thus import substitution is completely ruled out in production. Similarly, the export functions are not specified. It is not clear from the model's description whether export volumes or export values are given exogenously. For imported goods, the assumption of homogeneity (among the imported goods) along with non-competitiveness with the domestic goods is a strong assumption. For a developing country, the assumption of non-competitiveness might be true for some particular products but it cannot be assumed for all imported commodities. For example, amongst energy products imported furnace oil is a perfect substitute for domestically produced furnace oil and a good substitute for natural gas.

The formulation of household consumption behaviour by a Cobb-Douglas function appears inappropriate as almost all the micro level studies for Pakistan have assumed various forms of Linear Expenditure System (LES) to derive household's demand. The Cobb-Douglas consumption function does not differentiate between the demand for subsistence level and for luxury consumption. Consequently it does not allow for a minimum consumption level of goods (including energy). Therefore, for a change in the relative prices of energy and non-energy products, the Cobb-Douglas specification allows a higher substitution between energy and other goods relative to the LES demand function.

In the production function, energy products are treated as one of the intermediate goods that have fixed input-output coefficients. Therefore, substitution of energy with other factors of productions is ruled out. Because of the Leontief assumption, the mix of intermediate inputs does not depend on relative prices, thus

inter-fuel substitution is also not possible. This limitation is critical for the long-term simulation of alternative energy price scenarios as it prevents a certain fuel mix target being attained through changes in the relative prices of energy products.

Though Jalal has grouped households by urban and rural region, labour in production is not disaggregated by region. The demands for labour in the skilled and unskilled categories are the simple aggregates for labour supply from the two regions, implying a perfect substitution between urban and rural labour. This assumption may be appropriate in the long run but is arguably not valid in the short run.

Since the equations of the model are not documented, there are many things that are unclear. For example, it is not clear how the exports are treated in the model.

Jalal applied his model to evaluate the impacts of various reforms in energy prices in the long term. All the scenarios of reforms assumed increase in the prices of those energy products that are subsidised. Their prices were raised to their import-price levels. Thus these reforms eliminated only subsidies given on energy products. These simulations analysed the effects of increasing prices of some of the energy products rather than impact of reforms in energy prices. For example, the price of kerosene is increased to its import price level but the price of gasoline is not reduced to its import price level. Thus, the study does not compute the effects of removing the distortions in energy prices which are present in the form of product- source- and user-discriminating taxes.

The model is designed to simulate the long-term effects of changes in energy prices as capital is also assumed to be mobile among the sectors. It is generally perceived by the public, politicians and policy makers that elimination of subsidies has high adjustment costs in terms of slower economic growth and higher negative effects on the welfare of low-income groups who are major beneficiaries of these subsidies. Thus the planners and policy makers are more interested in the short- to medium-term effects of any price change on social equity and 'inflation'.

In his analysis of the results, Jalal focused mainly on two impacts: effects on

utility of households by income groups and 'inflationary effects' represented by the producers and consumer price indices. The major findings of Jalal's study are that elimination of subsidies on energy products has negative distributional effects and has insignificant 'inflationary effects' in the long-run. According to Jalal's model, elimination of subsidies from energy products, particularly from petroleum products put negative effects on low- and middle-income groups. However, these negative impacts can be compensated by giving subsidy on 'food' or removing import tariffs on intermediate commodities.

If we are interested to see the effects of the increase in the costs of energy supply, then the effects on real GDP and the sectoral compositions are important. As mentioned, all the scenarios in Jalal's study assume increases in energy prices but did not report effects on real GDP, the balance of trade and indirect tax revenues (where simulations were not revenue-neutral) for most of simulations. Jalal is selective in reporting of his simulation results. For only four simulations the impact on sectoral outputs are reported. In these four simulations all subsidies on energy products are removed cumulatively while these reforms are coupled with changes in import duties, subsidy on food and reduction in domestic tax on 'food & beverages' in three simulations alternatively. Though the net effect on GDP is not reported, changes in sectoral output show that there is a decline in output of 8 sectors (out of 13) in all simulations. Thus along with the four energy sectors (mining, petroleum, natural gas and electricity), there is a decline in the output of the textile, fertiliser, transport and services sectors in all the three cases. The effects on the trade balance are not discussed while the textile products are one of the major exports, and petroleum products are major import items.

3.3 Some Energy Models of other Developing Countries

Kim (1984) carried out a survey of energy models of developing countries. The survey reveals a variety of analytical techniques applied in different models. The scope of the survey is broad and it categorises the energy models developed for developing countries into six classes:

- (1) Project evaluation.
- (2) Technology assessment.
- (3) Energy sector assessment.
- (4) Macro simulation.
- (5) Economy wide optimisation model.
- (6) General equilibrium models.

These models were developed to address a variety of energy policy issues such as selection of a certain energy project, choosing an optimal mix of energy projects, investigation of particular features of the energy producing sectors, and forecasting of macro variables for the economy. Kim discussed strengths and weaknesses of each type of model and listed major features of some selected models from each category. The focal point of our study is the issues related to energy pricing policy and we intend to evaluate the impact of any change in this policy on the economy in a general equilibrium framework. Therefore in this section we discuss briefly some of the general equilibrium models used to carry out such an analysis for developing countries.

A general equilibrium appraisal of the impact of changes in energy prices was undertaken for Egypt by Nazli (1990); for Jordan by Blitzer (1984); for Sri Lanka by Blitzer and Eckaus (1985); for three types of developing countries by Blitzer (1986); for India by Sarkar & Kadeokdi (1988), and by Panda & Sarkar (1991); and for Mexico by Blitzer and Eckaus (1983b). For the oil exporting countries, Egypt and Mexico, the studies aimed to find out the macro-economic impact of the increase in energy prices that would occur if the subsidy on oil was removed. The aim of such a policy change would be to divert the domestic oil supply towards export and away from growing domestic consumption. For Jordan, an oil importing country, the model was designed to make medium-term forecasts of the economy for the two energy-pricing scenarios. In both the scenarios, world oil prices are assumed to increase at 2 per cent *per annum* in real terms, but in one of the scenarios the government removes the prevailing net subsidies on energy gradually over the medium term. The objective of the study on Sri Lanka was to model the energy-economy relationship in a general equilibrium framework. The model has been applied to make medium-term forecasts

of the economy for alternative scenarios of growth in world oil prices and the tariff policies on imported oil.

With reference to the scope of our study, reviewing these models and their applications offers the following points.

- (1) In none of the model a complete general equilibrium framework based on micro-economic theory has been specified. In all these models, energy-economy linkages are developed in the macro economic framework.
- (2) As pointed out by Devarajan (1988), the international trade theory is missing in most of the models. Thus, these models do not incorporate imports and exports demand functions. Currently most of the developing countries, especially in Asia, intend to de-regulate their economies and to liberalise their trade policies. Hence, incorporation of import- and export-competition becomes imperative in the economic modelling of these economies. An open-economy model can measure more precisely the micro- and macro-economic impacts of such policy changes. In particular, the analysis of short-term impacts is important to see the effects during the transitional period.
- (3) These models are highly aggregated. As pointed out by Devarajan (1988) that most of these energy models treat other sectors of the economy in fairly coarse fashion.
- (4) In all the models, petroleum products are aggregated into a single product.
- (5) In all the models the tax rate variables are highly aggregated. There are two types of taxes: sales tax and import tax. Since in these models petroleum products are aggregated into a single commodity, there is no provision to simulate the effects of differences in import tax or sales tax rates across petroleum products. For example in the model for Jordan, the effects of removing subsidies on petroleum products are simulated by removing these subsidies on aggregate by user types, because the subsidy rates and the tariff rates on petroleum products are not given by product types. These CGE models do not allow various types of source-, product- and user-discriminating tax on energy products.
- (6) Most of these models have been developed mainly to simulate the effects of an

increase in world oil prices or to forecast energy demand in the medium term. Regarding domestic energy price issues, the scope of most of these studies is limited to the issue of import tax on crude oil, or taxes on aggregate petroleum products.

- (7) The studies carried out for India evaluate the impact of changes in domestic energy prices. In these models it is assumed that energy prices are set by the government exogenously. The two studies evaluate the impact of increasing these exogenously given prices at a uniform rate for all consumers. Hence, distortions in the form of source- user- or product-discriminating taxes on energy products are not analysed, if there are any.
- (8) The prices in the models for Jordan and Sri Lanka are determined according to three rules: (a) domestic prices for traded goods are a linear function of border prices and tariffs and domestic tax rates; (b) the prices of some of the non-traded goods, such as transport and other services are set endogenously to clear the market; and (c) the price of electricity is given exogenously. The investment in the electricity sector is exogenously adjusted to ensure that the supply of electricity is equal to demand.
- (9) Only in the model for Sri Lanka the electricity sector is divided into hydro and thermal electricity sectors. The model assumes that the total electricity supply is a simple aggregation of electricity generation from the two sources. For medium term forecasting, investment in the thermal electricity sector is appended exogenously to meet the demand for electricity. Hence in the aggregation of electricity from different sources, the model does not take into account the changes in the relative prices of production, and the operational constraints of combining electricity generated from various types of technologies. We discuss the role of these two factors in electricity supply in Chapter 4 where we describe the two-level nested electricity supply structure in GE-PAK.
- (10) Only in the energy-economy model for India the income distributional effects are evaluated. The model computes Gini coefficients of the shares of three income groups categorised by agricultural income, non-agricultural wage

income and non-agricultural non-wage income. Since there is only one type of household in the Indian model, this distribution coefficient represents changes in the functional income distribution. The effects of changes in energy prices on consumption and income of households by income groups are not modelled.

Chapter 4

A Computable General Equilibrium Model of Energy-economy Interaction in Pakistan (GE-PAK)

4.1 Introduction

The objective of this chapter is to present GE-PAK; a multisectoral CGE model developed for Pakistan that incorporates energy-economy interactions. GE-PAK has been developed in the spirit of ORANI which is an Applied General Equilibrium (AGE) model for the Australian economy (Dixon *et al.*, 1982), and is widely used by academics and by economists in the government and private sectors.

GE-PAK contains detailed modelling of energy industries, along with other disaggregated industries, and energy-economy inter-relationships. The major features of the model are as follows.

- (1) Multiple-output industries and multiple-industry products.
- (2) Multiple household types.
- (3) Income mapping equations for multiple households and three other institutions.
- (4) Disaggregation of the labour market into urban and rural regions and an inter-region labour migration function.
- (5) Various types of indirect tax variable including user-discriminating taxes and implicit taxes on commodities with regulated prices.
- (6) Multiple production structures that incorporate factor-energy and inter-fuel substitution.
- (7) Substitution-possibility between domestic and imported commodities.
- (8) A two-level nested electricity supply structure.
- (9) Elasticity of 'social welfare' with respect to indirect tax revenues.

These features are discussed in detail in this chapter.

In Section 4.2 we present the structure of the model. The equations of the model are given in linear percentage change form. Therefore, we first discuss, in Section 4.3, an example of this form for a simple equation to elucidate the transformation procedure. Section 4.4 describes the dimensions of GE-PAK. We present the layout of the model's data-base through diagrams in Section 4.5. Section 4.6 contains the list of variables and parameters of the model. In this section we discuss the notational system for the names of variables and parameters. The equations of the model are divided into 31 blocks. Section 4.7 lists these equation blocks.

The equations of the model are discussed in detail in Sections 4.8 to 4.40. Each section is devoted to a block of equations. All the equations are reproduced in Appendix C (for ready reference) except the equations discussed in Section 4.14. In the model there are five special types of production structure; each relevant to a set of industries. Besides these special structures, there is a default production structure. In Appendix C we present only the default production structure instead of the five special types. In the discussion of new equations valid for a particular set of industries, we identify which equation or equations in the default structure, these new equations will replace. This makes our job of 'closing' the model easier. In our model, the number of variables exceeds the number of equations. To close the model, we have to assume a set of variables exogenous to the model which makes the number of endogenous variables equal to the number of equations. Section 4.41 presents a table listing our selected exogenous variables that represents one plausible way to close the model. There are certain rules to be followed to categorise the variables into exogenous and endogenous groups; section 4.41 discusses these rules.

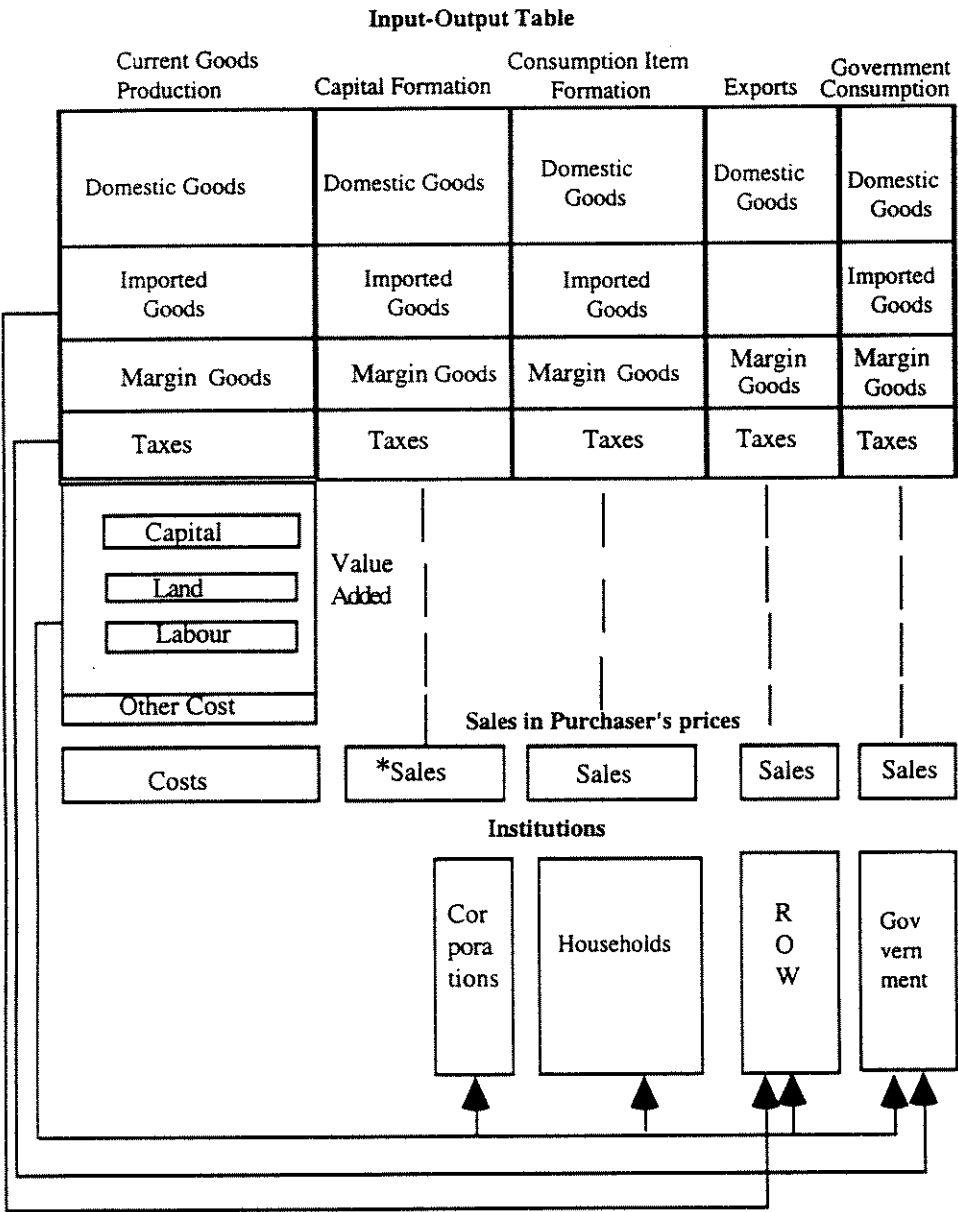
Section 4.42 discusses appropriate interpretation of the model's results for a hypothetical case while Section 4.43 discusses the solution procedure of the model.

In Section 4.44 we briefly discuss the steps involved in computer implementation of a model using GEMPACK (General Equilibrium Modelling Package); the computer software used to implement and solve GE-PAK.

4.2 Model's Structure

GE-PAK belongs to the Johansen class of models. It is built around a social accounting matrix which contains a detailed input-output table and income-expenditure accounts of 4 types of institutions: households; government; corporations; and the rest of the world (ROW).

Figure 4.1 Structure of the Model



* Sales of investment goods are made from the savings of all the institutions.

In this section we outline the core structure of our model shown in Figure 4.1. The upper part of the figure shows the input-output table and shows commodity flows by the usage. Commodities are used as intermediate goods in current production, for capital formation, for consumption-items formation (each item is formed by several commodities and these items are consumed by households only), for exports and for government consumption. The bottom part of Figure 4.1 shows income matrices of the institutions which own factors of production. The first column shows production-costs accounts of current production. The three primary-factors rows (capital, land and labour) show the employment of these factors in current production. The arrows from column 1 of the input-output table show factor's payments received by the institutions. In the input-output table an arrow coming from the imported-goods blocks to ROW's income block shows that revenues from these sales are received by the rest of the world.

The institutions spend their income on the purchase of commodities shown in the sales blocks. The broken lines indicate that the sales of commodities in purchasers' prices are basic values (production costs) of commodities plus margin costs and indirect taxes on sales. The sales of commodities for consumption-item formation, exports, and government consumption, correspond to households' expenditure, purchase of commodities by ROW and government expenditure respectively. We assume that current goods producers are also investors. These producers also buy goods and services for capital formation. The total value of these sales is equal to the savings of the domestic institutions (households, corporations and government) plus the net transfer of resources from ROW. This transfer of resources fills the gap between the aggregate saving of domestic institutions and exogenously given investment.

The structure of the GE-PAK is represented by equations describing for a given time period:

- producers' demands for produced inputs and primary factors;
- producers' supplies of commodities;

- demands for inputs for capital formation by investors;
- demands for inputs for consumption-items formation;
- demands for consumption-items by households;
- demands for exports;
- demands for government consumption;
- the relationship of basic values (production cost) to purchasers' prices;
- market clearing equations for commodities and primary factors;
- income of households, government and other institutions by source; and
- numerous macroeconomic variables.

Demand and supply equations for private-sector agents are derived from the solutions to the optimisation problems (utility maximisation, cost minimisation) which are assumed to underlie the behaviour of agents in conventional neo-classical microeconomics. Agents are assumed to be price takers, and producers are assumed to operate in competitive markets which prevent the earning of pure profits.

The input demand equations for public sector agents (such as electricity producers) are also derived from the solution to the cost minimisation problem. The only difference between the commodities produced by the private-sector agents and the public-sector agents is in the determination of sale prices. The prices of commodities produced solely by private-sector agents are determined by market forces, while the prices of commodities produced by public-sector agents are regulated by the government. Producers in both sectors are price takers and assumed to minimise the costs of production. Basic prices (production costs) of commodities produced in the public sector are determined endogenously in the model. We treat the differences between basic prices and the regulated sales prices of these commodities as implicit taxes. We have incorporated these implicit taxes in our model. We assume that there is an implicit tax on these commodities which are determined endogenously by the market-determined production cost relative to the regulated prices of these commodities.

Along with the above behavioural equations, the income determining equations in the model map factor incomes to the five institutions (four domestic and one foreign): households; corporations; government; and ROW. Factors of production employed in the industries are owned by these institutions. Each institution's income is determined by its exogenously given endowment of factors and the endogenously determined factor prices. In our model there are three types of primary factors; labour, capital and land. Labour is owned only by households while capital and land are owned by all the five institutions. Every institution has income from other sources besides returns on factors of production. For example, the government gets indirect tax revenues and the households get dividends from corporations.

On the consumption side, total consumption of each household type is determined by its income while its average propensity to consume is fixed. The demands for commodities are then determined under expenditure constraint for each household group. The model incorporates demand function for 14 types of household. Though government income has been defined separately, there is no budget constraint on its expenditure. Government's demands for commodities (for current expenditure) are assumed to be in direct proportion to real private consumption.

4.3 An Example of Linear Percentage Change Form

Many of our model's equations are non-linear, for example—demand depends on the price ratio. However, following Johansen (1960) and Dixon *et al.* (1982) the model is solved by representing it as a series of linear equations relating percentage changes in variables of the model. Sections 4.8 to 4.40 contain this linear equation system. In this section we discuss the procedure to transform an equation system given in the levels into linear form.

To illustrate the basic principle of linearisation we consider a very simple equation system that aggregates the rental value of capital in the economy. The rental value of capital in industry j , $CAPREV_j$, is defined as

$$CAPREV_j = P1CAP_j \times X1CAP_j, \quad (4.3.1)$$

where $P1CAP_j$ and $X1CAP_j$ are price and quantity of capital in industry j . Hence an aggregation of the rental value of capital in all industries, *i.e.*, $CAPREV\_j$, can be defined as

$$CAPREV\_j = \sum_{j \in IND} P1CAP_j \times X1CAP_j, \quad (4.3.2)$$

where IND is the set of all industries in the economy. Using first principles, the levels equation (4.3.2) is turned into percentage-change form by first taking the total differential,

$$dCAPREV\_j = \sum_{j \in IND} P1CAP_j \times dX1CAP_j + X1CAP_j \times dP1CAP_j.$$

Variables in percentage-changes form, *i.e.*, $caprev\_j$, $plcap_j$ and $x1cap_j$ are defined *via*:

$$caprev\_j = 100 \frac{dCAPREV\_j}{CAPREV\_j},$$

or by rearranging

$$dCAPREV\_j = \frac{CAPREV\_j \times caprev\_j}{100}.$$

$$\text{Similarly } dP1CAP_j = \frac{P1CAP_j \times plcap_j}{100}, \text{ and } dX1CAP_j = \frac{X1CAP_j \times x1cap_j}{100}.$$

Thus our sample equation (4.3.2) becomes:

$$\frac{CAPREV\_j \times caprev\_j}{100} = \sum_{j \in IND} P1CAP_j \frac{X1CAP_j \times x1cap_j}{100} + X1CAP_j \frac{P1CAP_j \times plcap_j}{100},$$

which can be rearranged to arrive at

$$CAPREV\_j \times caprev\_j = \sum_{j \in IND} (P1CAP_j \times X1CAP_j) \times (plcap_j + x1cap_j).$$

Using the $CAPREV_j$ definition from equation (4.3.1) we write

$$caprev\_j = \frac{1}{CAPREV\_j} \sum_{j \in IND} CAPREV_j \times (plcap_j + x1cap_j), \quad (4.3.3)$$

which is the form in which equations of the model are given.

In practice, formal derivations such as given above are often unnecessary for the conversion of equations. Most equations in percentage-

change form follow standard patterns. Some of these are shown in Table B1 in Appendix B.

We use this example to also list the rules applied to define names of the variables and coefficients of the model. There are four such rules which are given below.

- (1) All the variable names are in lower-case.
- (2) All the coefficients are defined on flows of data matrices in the base year, and the names of these matrices are in upper-case.
- (3) All the names of variables and coefficients defined in sets have subscripts.
- (4) To define an aggregation of a variable or coefficient over a set, instead of giving a new name, we have appended an underscore "_" at the end of the variable or coefficient name along with a subscript over which the variable or coefficient is aggregated. For example, the coefficient $CAPREV_j$, aggregated on subscript j is written as $CAPREV\_j$.

One of the advantages of a linearised system is its simplicity. This is evident when writing equations which have complicated functional forms. For example, in the equation system of an input demand function: the CES input demand equations for a producer j who makes output $X0_j$ from $X1_{ij}$ inputs (i is the element of commodity set COM) with prices $P1_{ij}$. In the levels the equations are (see Appendix A for the derivation of this demand function):

$$X1_{ij} = X0_j \delta_i^{1/(\rho+1)} [P1_{ij} / P1\_j]^{-1/(\rho+1)}, \quad i \in \text{COM}, j \in \text{IND}, \quad (4.3.4)$$

where

$$P1\_j = \left(\sum_{i \in \text{com}} \delta_i^{1/(\rho+1)} P1_{ij}^{\rho/(\rho+1)} \right)^{(\rho+1)/\rho} \quad j \in \text{IND}. \quad (4.3.5)$$

The δ_i and ρ are behavioural parameters.

In a linear equation system, the percentage change form of equations (4.3.4) and (4.3.5) are ,

$$x_{ij} = x0_j - \sigma (p1_{ij} - p1\_j), \quad i \in \text{COM}, j \in \text{IND}, \quad (4.3.6)$$

$$\text{and } p1_{ij} = \frac{1}{\sum_{i \in \text{COM}} V1BAS_{ij}} \sum_{i \in \text{COM}} V1BAS_{ij} p1_{ij}, \quad j \in \text{IND}, \quad (4.3.7)$$

where $V1BAS_{ij} = X1_{ij} \times P1_{ij}$; the value of commodity i input in industry j in the data-base (see Appendices A and B for linearisation principles).

Apart from its simplicity in constructing a model, the linearised approach has two further advantages.

- It allows free choice of which variables are to be exogenous or endogenous. Many levels' algorithms do not allow this flexibility.
- To reduce AGE models to manageable size, it is often necessary to use model equations to substitute out matrix variables of large dimensions. In the linear system we can always make any variable the subject of any equation in which it appears. Hence substitution is a simple mechanical process. In fact, the computer software, GEMPACK, that has been used to solve our model, performs this routine algebra for the users. This allows us to specify the model in terms of its original behavioural equations, rather than in reduced form. This reduces the potential for error and makes equations easier to check.

Table 4.1a Names of Sets and Corresponding Subscripts

Set Name	Subscript	Elements
CAP	c	Capital types: (1) Non-corporate capital, (2) Private-corporate capital, (3) Public-corporate capital, (4) Government capital, (5) ROW capital, and (6) Capital in dwellings.
COM	i	One hundred and thirty-one commodities (see Table E2 in Appendix E for commodity names).
COR	o	Corporations: (1) Private and (2) Public.
FAC	f	Factors of production: (1) Labour, (2) Capital, and (3) Land.
INC	n	Households income groups: (1) Self-employed-low-income, (2) Self-employed-middle-income, (3) Self-employed-high-income, (4) Employed-low-income, (5) Employed-middle-income, (6) Employed-high-income, and (7) Others.
IND	j	One hundred and twenty eight industries (see Table E1 in Appendix E).
ITM	k	Fifty three consumption items (see Table E3 in Appendix E).
LND	d	Land types: (1) Non-corporate, (2) Private-corporate, (3) Public-corporate, (4) Government, and (5) ROW.
PRF	p	Professional groups of labour: (1) Skilled and (2) Unskilled.
REG	r	Regions: (1) Rural, and (2) Urban.
SRC	s	Source s of commodity supply: (1) Domestic, and (2) Imported.

4.4 Dimensions of the Model

In this section we give a summary of the model's dimensions. In the model there are eleven sets containing names of commodities, industries, consumption items (from now on referred to as items only), *etc.* Table 4.1a gives the names of these sets, their corresponding subscripts, and their elements (see Appendix E for the lists containing names of industries, commodities and items). Table 4.1b gives the names of subsets, their corresponding subscripts, and their elements.

Table 4.1b Names of Subsets and Corresponding Subscripts

Subset Name	Subscript	Elements
ADM	a	A subset of commodities that have administered prices; natural gas, petroleum products, cement, fertiliser and electricity.
ERG	i	A subset of commodities containing all commercial energy products.
FUL	i	A subset of commodities containing all energy products except electricity.
MAR	m	A subset of commodities that are used as margin commodities; wholesale & retail, road transport, and rail transport.
NONMAR	m	The complementary subset of MAR.
NONIELE	j	All industries other than electricity industries.
NONCELE	i	All commodities other than electricity.
IAGR	j	Agricultural industries (see Table E1 for names of industries in this subset).
ICCY	j	Combined cycle electricity industry.
IELE		All electricity industries (see Table E1 for names of industries in this subset).
IGST	j	Gas turbine electricity industry.
IHYD	j	Hydro electricity industry.
IIND	j	All mining, manufacturing and construction industries.
IMFLX	j	More-flexible electricity industries: hydro and gas turbine electricity industries.
ILFLX	j	Low-flexible electricity industries: combined cycle and steam electricity industries.
IRDT	j	Road transport industry.
ISER	j	Services industries.
ISTM	j	Steam electricity industry.

4.4.1 Number of Industries

There are one hundred and twenty-eight industries that produce one hundred and thirty-one commodities. The set IND contains the names of all industries. Multiple production is confined to the oil & gas, and the refinery industries. Electricity is a single commodity which is produced by multiple industries. The subset IELE contains the names of four electricity industries. Each of the remaining industries produces a unique commodity. We have defined five subsets of industries that differ in their energy-factor and inter-energy substitution structure. The names of these subsets and their elements are listed in Table 4.1b.

4.4.2 Number of Commodities

Of the one hundred and thirty-one commodities, there are three margin commodities, which are required to facilitate the flows of other commodities from producers (or importers) to users. The subset MAR contains the names of these margin commodities.

4.4.3 Number of Items

In the model there are fifty-three items which are formed by one hundred and thirty-one commodities supplied by two sources. Households demand these items rather than commodities (the consumption data in the original social accounting matrix was collected on fifty-three consumption items). The item names are given in set ITM.

4.4.4 Labour Categories

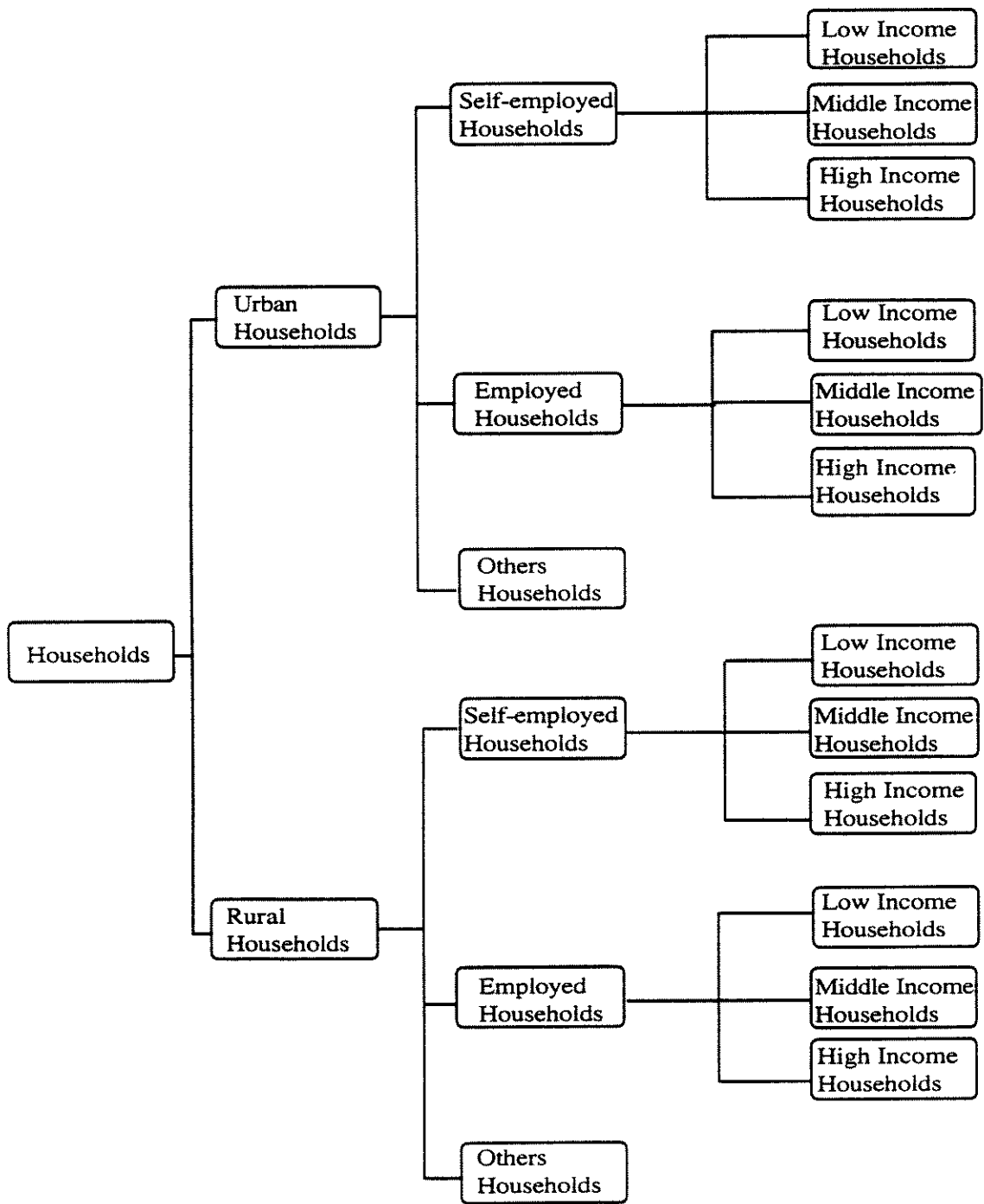
There are four types of labour which are categorised by two regions, and within a region by two professions, *i.e.*, skilled and unskilled. The set REG contains region names while the set PRF contains profession names.

4.4.5 Capital and Land Categories

In the model there are six types of capital and five types of land to categorise these two factors by ownership. For example private-corporate

capital refers to capital owned by the private corporations (see Chapter 5 Section 5.3.15 for details).

Figure 4.2 Household Categories



4.4.6 Household Categories

The model recognises fourteen types of household. Figure 4.2 illustrates the taxonomy of household types. All households are divided into

two regions: urban and rural. Households in each region are grouped by the employment status of the head of the family. There are three employment categories: self-employed, employed, and others. Households in the first two employment categories are distributed into three income groups: low, middle, and high. In the model we have grouped households from three employment categories and three income groups within a region, into one category, and referred to them as seven types of household within a region. The names of household types by income groups are given in the set INC.

4.4.7 Selection of the Base Year

To implement the model, we have selected 1983-84 as the bench mark year as the most recent, comprehensive and consistent data set was available in the form of a social accounting matrix. It is a 273×273 matrix developed by Dhanani (1986a, 1986b) as a part of a research program to analyse agricultural policy in Pakistan.

However, the Social Accounting Matrix (SAM) of Pakistan in its original form was not fully suitable to GE-PAK's specifications. Therefore, we have expanded and modified it. The SAM was developed in 1986 and since then some more supplementary data has been published. We have used these new data sources to update certain parts of the SAM which were not constructed properly due to lack of information in 1986. We discuss construction of our data base in Chapter 5. However, to describe our model we discuss the structure of the data base (built on that SAM) in the next section.

4.5 Input-Output Data Base

Figures 4.3 and 4.4 are schematic representation of the model's input-output data base. It reveals the basic structure of the model. Figures 4.5 to 4.7 show how input-output matrices are used to compute various other data matrices. In the model's specification, we use these data matrices to define coefficients in the equations. In the following paragraphs we first discuss the input-output data matrices and then discuss the new matrices computed from

them. Figures 4.5 to 4.7 contain the names of data matrices which have been used in Section 4.8 to 4.40 where equations of the model have been defined.

The columns in Figure 4.3 (representing an absorption matrix) identify the following agents:

- (1) domestic producers divided into industries;
- (2) investors divided into industries;
- (3) consumption-items producers;
- (4) a foreign purchaser representing aggregate demand for exports; and
- (5) an 'other' final consumer, broadly corresponding to government consumption.

The rows in Figure 4.3 show the structure of the purchases made by each of the agents identified in the columns. Each cell in the absorption matrix contains the name of the data matrix or the data vector. These data matrices and vectors contain base-year values of commodities, margin commodities, indirect taxes and primary factors for a group of users. Note, that primary factors are used only in current production.

The first row in Figure 4.3 shows basic value (production costs) of commodities by consumer categories. The matrices V1BAS to V5BAS contain these values. Each commodity can be obtained locally or imported from overseas. The source-specific commodities are used by industries as inputs to current production, capital formation, and items formation. These commodities are also used by the government. Only domestically produced goods appear in the export-column which shows that only domestically produced commodities are exported. The second row in Figure 4.3 shows the matrices containing flows of margin-commodities used to supply commodities from production point to consumers. The matrices V1MAR to V5MAR contain values of m margin commodities for each consumer category.

Figure 4.3 Flows in the Data Base

		1	2	3	4	5
		Producers	Investors	Items producers	Exports	Other
Size		← IND →	← IND →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ COM × SRC ↓	V1BAS _{isj}	V2BAS _{isj}	V3BAS _{is}	V4BAS _i	V5BAS _{is}
Margins	↑ COM × SRC × MAR ↓	V1MAR _{isj}	V2MAR _{isj}	V3MAR _{is}	V4MAR _i	V5MAR _{is}
Taxes	↑ COM × SRC ↓	V1TAX _{isj}	V2TAX _{isj}	V3TAX _{is}	V4TAX _i	V5TAX _{is}
Labour	↑ REG × PRF ↓	V1LAB _{rpj}	COM Commodities set IND Industries set SRC Sources set; Domestic, Imported MAR Margin commodities set REG Regions set; Rural, Urban PRF Professions set; Skilled, Unskilled LND Land types set CAP Capital types set			
Capital	↑ CAP ↓	V1CAP _{cj}				
Land	↑ LND ↓	V1LND _{dj}				
Other Costs	↑ 1 ↓	V1OCT _j				

Joint Production Matrix	
Size	← IND →
↑ COM ↓	MAKE _{ij}

Import Duty	
Size	← 1 →
↑ COM ↓	V0TAR _i

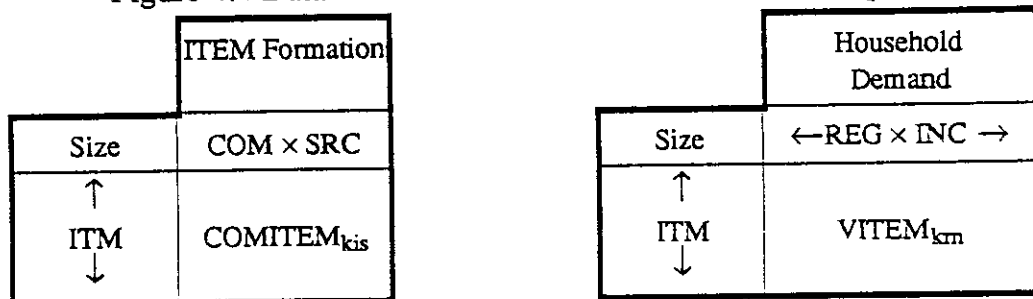
Indirect taxes on commodities are payable on the purchases made by five consumer categories. The matrices V1TAX to V5TAX in Figure 4.3 give the indirect sales taxes paid by each consumer category on commodities supplied from two sources.

Current production requires inputs of three types of primary factors: labour, fixed capital, and land. The matrix VILAB contains the wage bill for labour by profession and region. Similarly the matrices V1CAP and V1LND contain rental values of capital and land for each industry. The vector of 'other costs' category, V1OCT, gives various miscellaneous industry-expenses in current production.

In principle, each industry is capable of producing all commodities. The make matrix in Figure 4.3 shows the output value of each commodity by industries. However, only two industries, *i.e.*, the oil & gas industry and the refinery industry, have multiple products in our data base (see Chapter 5 for details). Similarly, electricity is the only commodity which is produced by more than one industry; four different electricity industries are defined in the model.

Finally the import taxes are assumed to be levied at rates which vary by commodity but not by users. The import tax revenues by commodities are given in the vector V0TAR.

Figure 4.4 Data flows on Item Formation and Consumption



In the model it is assumed that household demand is for consumption items which are formed by the domestic and imported commodities. The item formation does not require primary factors. In the data base there are two sub-

matrices The VITEM matrix in Figure 4.4 gives expenditure on consumption by household types. The columns in the consumption matrix VITEM identify households by region and income groups, and its rows represent items. Each cell in $VITEM_{km}$ gives the value of item k consumed by households from region r in income group n . The $COMITEM_{kis}$ matrix gives values of commodity-use by source for item formation. The rows in this matrix represent items, and columns show commodities by sources. For example, each element of $COMITEM_{kis}$ shows the value of commodity i from source s used to produce item k . The commodity-usage by source in V3BAS matrix (in Figure 4.3) is an aggregation of commodity-use for item formation given in $COMITEM_{kis}$.

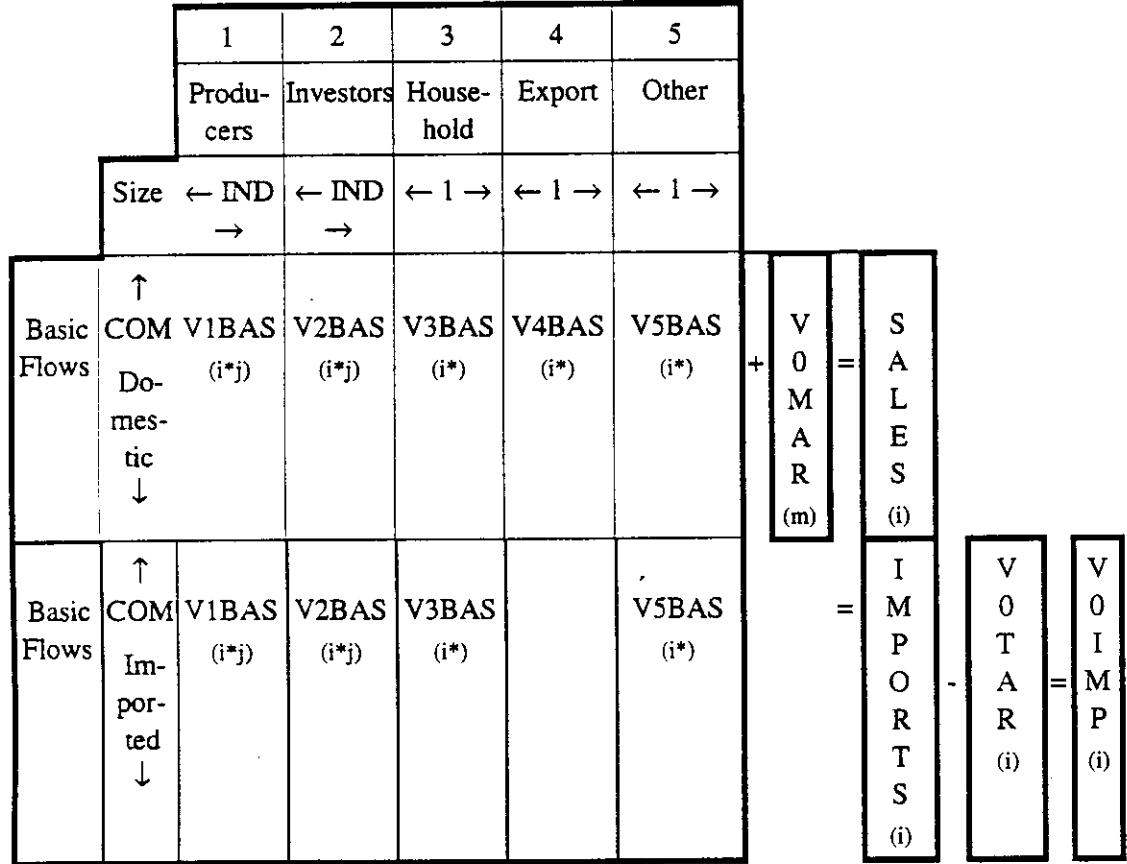
Figure 4.5 Data Flows in Input-output Data base in Purchasers' Prices

		1	2	3	4	5
		Producers	Investors	Items formation	Exports	Other
Size		← IND →	← IND →	← 1 →	← 1 →	← 1 →
Values in Purchaser prices	COM × SRC	PUR1 _{isj}	PUR2 _{isj}	PUR3 _{is}	PUR4 _i	PUR5 _{is}
Value Added		V1PRM _j				
Other Costs	↑ 1 ↓	V1OCT _j	COM Commodities set. IND Industries set. SRC Sources set: Domestic, Imported.			
		COSTS _j				

As discussed, expenditure by each consumer category is disaggregated into three parts in the data base: basic prices (production costs) value, costs of margins and indirect taxes. We compute consumption in purchasers' prices by adding up these three components. Matrices containing expenditure in purchasers' prices are reported in Figure 4.5. These purchasers' price values are given by commodities, sources and user categories. For example matrix PUR1 in Figure 4.5 is the sum of V1BAS, V1MAR and V1TAX for the consumption of commodity i , from source s , by industry j .

The vector $V1PRM$ in the first column in Figure 4.5 is the sum of primary-factor costs in each industry. $V1PRM$ for industry j is the sum of $V1LAB$, $V1CAP$ and $V1LND$ for industry j . The total cost of production in industry j is given in the production-costs vector $COSTS$, which is the sum of $PUR1$ for all commodity from each source, $V1PRM$ and $V1OCT$ for industry j .

Figure 4.6 Data Flows on Consumption of Domestic and Imported Commodities



Note: Characters in brackets are subscripts.

The sales vector $SALES$ in our model contains the basic value (production costs) of total consumption of commodity i by all users from domestic supply. Figure 4.6 shows that the sale of commodity i , is the sum of $V1BAS$ to $V5BAS$ and $V0MAR$ for all users. Because some commodities are also used as margin-goods, the $V0MAR$ vector is added into the sum of $V1BAS$ to $V5BAS$ to arrive at $SALES$ vector. As shown in Figure 4.7, the $V0MAR$ vector contains the aggregate costs of margin-goods consumed by all users.

The aggregated basic values (cost of supply) of imported commodities are given in vector IMPORTS. Figure 4.6 shows that IMPORTS vector is sum of V1BAS to V5BAS for imported commodities, and includes import taxes. The import costs of commodities net of tariffs are given in the vector VOIMP.

Figure 4.7 Data Flows on Consumption of Margin-Goods

		1	2	3	4	5		
		Producers	Investors	Households	Export	Other		
Size		← IND →	← IND →	← 1 →	← 1 →	← 1 →		
Basic Flows	↑	COM	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	= V O M A R (m)
	Do- mes- tic ↓	(i)i*j	(i*j)	(i*)	(i*)	(i*)	(i*)	

Note: Characters in brackets are subscripts.

4.6 Variables, Coefficients and Parameters of the Model

The names of the variable are listed alphabetically in Table 4.2 along with a brief description and their dimensions. Unless otherwise stated, all variables are percentage changes — to indicate this, their names are written in a lower-case letter. For variables that may change sign in the level, such as trade balance, we prefer to use ordinary change (not percentage). For the variables that give ordinary changes (rather than percentage), a qualifier, 'del' precedes in the names of those variables to identify them. Along with this general principle, the variables are assigned names in a systematic manner. As far as possible, names for variables conform to a system in which each name consists of 2 or more parts, as follows:

first, a letter indicating the type of variable, for example,

a	technical change,
c	consumption,
d	dividend rate,
e	endowment,
f	shift variable,
p	price in Rs.,
t	power of tax,
u	unemployed,
x	input/output quantity,
y	income;

second, one of the digits 0 to 6 indicating the user, *i.e.*,

1	current production,
2	investment,
3	item formation,
4	exports,
5	'other' (Government),
0	all users

or user distinction irrelevant,

or three characters indicating institution. *i.e.*,

hou	household,
cor	corporation,
gov	government,
row	rest of the world;

third, three letters giving further information, for example,

cap	capital,
erg	energy products aggregate on commodity subset ERG,
frt	fertiliser,
ful	fuels aggregate on commodity subset FUL,
inv	investments,
lab	labour,
lnd	land,
mar	margins,
pmp	energy for pumping,
prm	primary factors aggregate,
rev	indirect tax revenues,
tot	average over all subscripts,
wag	wages.

In all the variable names an underscore, *i.e.* "_", followed by one or more subscripts indicates that the variable is aggregated on that subscript or subscripts. For example, the variable p1lab_r_{pj} is defined as aggregated wage rates of regions, *i.e.*, p1lab_{r_{pj}} is aggregated over the r subscript.

Table 4.2 lists the variable names alphabetically. The first column gives the name of the variable or variable array. The second column gives the name of the set or sets on which that variable array is defined. A brief definition of the variable is given in the third column.

Table 4.2 List of Variables

Variable Name	Set/Sets Name	Description of Variables
a_j	IND	Index of all-input-augmenting technical changes in current production.
$a1_{isj}$	COM $\times$ SRC $\times$ IND	Input-augmenting technical change for commodity i from source s in current production in industry j.
$a1_{sj}$	COM $\times$ IND	Input-augmenting technical change for commodity i in current production in industry j.
$alcap_{cj}$	IND	Capital-input augmenting technical change in current production in industry j.
$allab_{rpj}$	REG $\times$ PRF $\times$ IND	Labour-augmenting technical change for labour from region r, of profession p, in current production in industry j.
$allab_{pj}$	REG $\times$ IND	Labour-augmenting technical change for labour from region r in current production in industry j.
$allab_{rpj}$	IND	Labour-input augmenting technical change in current production in industry j.
$allnd_{dj}$	IND	Land-augmenting technical change in current production in industry j.
$almar_{isjm}$	COM $\times$ SRC $\times$ IND $\times$ MAR	Margin-good-m-augmenting technical change for commodity-i supply to industry j from source s for current production.
$aloc_{tj}$	IND	"Other costs" augmenting technical change.
$alprm_j$	IND	All-primary-factors augmenting technical change.
$a2_{isj}$	COM $\times$ SRC $\times$ IND	Input-augmenting technical change for commodity i from source s for capital formation in industry j.
$a2_{sj}$	COM $\times$ IND	Input-augmenting technical change for commodity i for capital formation in industry j.
$a2_{isj}$	IND	All-input-augmenting technical change for capital formation in industry j.
$a2mar_{isjm}$	COM $\times$ SRC $\times$ IND $\times$ MAR	Margin-good-m-augmenting technical change for commodity-i supply to industry j, from source s, for capital formation.

....continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
$a3mar_{ism}$	$COM \times SRC \times MAR$	Margin-good-m-augmenting technical change for commodity-i supply, from source s, for item formation.
$a4mar_{im}$	$COM \times MAR$	Margin-good-m-augmenting technical change for commodity-i supply for exports.
$a5mar_{ism}$	$COM \times SRC \times MAR$	Margin-good-m-augmenting technical change for commodity-i supply for government consumption.
$aitem_{km}$	$ITM \times REG \times INC$	Change in the taste of household for item k consumption by household from region r and income-group n.
$aitemlux_{km}$	$ITM \times REG \times INC$	Change in the taste of household for consumption of item k, for luxury, by region and household type.
$aitemsub_{km}$	$ITM \times REG \times INC$	Change in the taste of household in item k, for subsistence consumption, by region and household type.
apc_m	$REG \times INC$	Average propensity to consume of household type n in region r.
$atot_j$	IND	All-input-augmenting technical change in current production.
$caprev$	1	Aggregate payments to capital.
$chou_m$	$REG \times INC$	Consumption of household by region and household type.
$chou\_m$	1	Aggregate household consumption.
$chour_m$	$REG \times INC$	Real consumption of household by region and household type.
$chour\_m$	1	Real aggregate household consumption.
$delB$	1	Trade balance in billion Rs.
$delLON$	1	Balance of payments in billion Rs.
$drate_o$	COR	Dividend rate of corporations.
$ecorcap_{oc}$	$COR \times CAP$	Corporations' endowment of capital by type.
$ecorInd_{od}$	$COR \times LND$	Corporations' endowment of land by type.
$egovcap_c$	CAP	Government's endowment of capital by type.

.....continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
egovind _d	LND	Government's endowment of land by type.
ehoucap _{mc}	REG × INC × CAP	Households' endowment of capital by type.
ehoulab _{mp}	REG × INC × PRF	Households' endowment of labour by professions.
ehoulnd _{md}	REG × INC × LND	Households' endowment of land by type.
erowcap _c	CAP	Capital endowment of ROW in Pakistan.
erowlnd _d	LND	Land endowment of ROW in Pakistan.
exp	1	Exports earnings.
expvol	1	Exports volumes index.
floct _j	IND	Shift in "other costs" input in current production.
f1wag _{jrp}	REG × PRF	Shift in real wages of labour from region and of profession p.
f5 _{is}	COM × SRC	Shift in commodity-i consumption by government from source s.
f5tot	1	Shift in commodity-i consumption by government from both the sources.
fep _i	COM	Shift in foreign currency ,Freight on Board (FOB), price of exports.
feq _i	COM	Shift in volume of commodity-i exports.
fhouhou _{mu} v	REG × INC × REG × INC	Shift in inter-household transfers.
fp0pub _a	ADM × SRC	Shift in the power of tax rate on commodities with regulated prices.
fr0 _j	IND	Shift in rate of returns on fixed investment in industry j.
fxlcap _{cj}	IND	Shift in investment (units of capitals) in industry j.

..... continued

Table 4.2 (continued)

Variable Name	Set/Sets name	Description of Variables
fyhougov _m	REG × INC	Shift in income of households from government.
fyhourow _m	REG × INC	Shift in income of households from ROW.
gdpexp	1	Gross domestic product; expenditure side.
gdpinc	1	Gross domestic product; income side.
gdpreal	1	Real Gross domestic product; expenditure side.
gnpexp	1	Gross national product; expenditure side.
gnpinc	1	Gross national product; income side.
hsize _m	REG × INC	Number of persons per households.
imp	1	Imports bill.
impvol	1	Import volume index.
inv	1	Aggregate investments.
invr	1	Real aggregate investments.
labrev	1	Aggregate labour wage bill.
lambda _{rp}	REG × PRF	Aggregate employment by profession and region.
lambda _{pr}	REG	Aggregate employment by region.
lambda _{rp}	PRF	Aggregate employment by profession.
lndrev	1	Aggregate rental value of land.
luxexp _m	REG × INC	Household luxury expenditure by region and household type.
nfi	1	Net-factor payments from ROW.
octrev	1	Aggregate "other costs" in current production.
oth	1	Aggregate government consumption.
othr	1	Real aggregate government consumption.

.....continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
p0dom _i	COM	Basic price (production costs) of domestic good i.
p0imp _i	COM	Basic price (supply costs) of imported good i.
p0ind _j	IND	Weighted-average price of outputs of industry j in current production.
p0is	COM × SRC	Basic price of commodity by source.
plcap _{cj}	CAP × IND	Rental price of capital by type in current production by industry.
plcap _{cj}	IND	Average rental price of capital in current production by industry.
plcap _{jc}	CAP	Rental price indice of capital by type.
pllab _{rpj}	REG × PRF × IND	Wages of labour by region, profession and industry.
pllab _{jrp}	REG × PRF	Wage-rate indices by region and profession.
pllab _{pj}	REG × IND	Average wage rates by region and industry.
pllab _{rpj}	IND	Average wage rates by industry.
pllabr _{jmp}	REG × INC × PRF	Real-wage-rate indices by profession for households by region and household type.
pllabr _{jrp}	INC × PRF	Real-wage-rate indices for households by profession and household type.
pllnd _{dj}	LND × IND	Rental-price of land by type in current production by industry.
pllnd _{dj}	IND	Average rental price of land in current production by industry.
pllnd _{jd}	LND	Rental price indice of land by type.
ploct _j	IND	Basic price of "other costs".
plprm _j	IND	Average primary factor cost by industry.
plis _j	COM × SRC × IND	Purchaser price of commodity i, by source s, for current production.

.....continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
$p1_{sij}$	COM $\times$ IND	Purchaser price of commodity i, for current production.
$p2_{isj}$	COM $\times$ SRC $\times$ IND	Purchaser price of commodity i, by source s, for capital formation.
$p2_{sij}$	COM $\times$ IND	Purchaser price of commodity i, for capital formation.
$p2_{isj}$	IND	Purchaser price of investment good i for industry j.
$p3_{is}$	COM $\times$ SRC	Purchaser price of commodity i, by source s, for item formation.
$p5_{is}$	COM $\times$ SRC	Purchaser price of commodity i, by source s, for government consumption.
$p3_{item\_ski}$	ITM $\times$ COM	Purchaser price of commodity i for item k formation.
pe_i	COM	Foreign currency (FOB) price of exports by commodities.
$perconr_m$	REG $\times$ INC	Real <i>per capita</i> consumption.
ϕ_i	1	Exchange rate; Rs. per US \$.
$pitem_k$	ITM	Purchaser price of item k.
pm_i	COM	Foreign currency (CIF) price of imports.
q_{mp}	REG $\times$ INC $\times$ PRF	Number of households by region and household types with profession p.
q_{p_m}	REG $\times$ INC	Number of households by region and household type.
$q_{r_{np}}$	INC $\times$ PRF	Number of households by household types and profession.
$r0_j$	IND	Rate of return on fixed investment by industry j.
$rtot$	1	Average rate-of-return on fixed investment.
sav	1	Aggregate savings of domestic institutions.
$savcor_o$	COR	Corporations' savings.
$savgov$	1	Government's savings.
$savhou_m$	REG $\times$ INC	Savings of households by region and household types.

.... continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
t0	1	Power of sales tax on all commodities and all users.
t _{is}	COM × SRC	Power of sales tax on commodity i, from source s.
t _{1isj}	COM × SRC × IND	Power of sales tax on commodity i, from source s, for current production in industry j.
t _{1_isj}	1	Power of sales tax on all commodities for current production.
t _{1_eij}	COM × IND	Power of sales tax on commodity i, for current production in industry j.
t _{2isj}	COM × SRC × IND	Power of sales tax on commodity i, from source s, for capital formation.
t _{2_isj}	1	Power of sales tax on all commodities, for capital formation.
t _{2_eij}	COM × IND	Power of sales tax on commodity i, for capital formation in industry j.
t _{3is}	COM × SRC	Power of sales tax on commodity i from source s, for item formation.
t _{3_is}	1	Power of sales tax on all commodities, for item formation.
t _{3_ei}	COM	Power of sales tax on commodity i for item formation in specific.
t _{4i}	COM	Power of sales tax on commodity i for exports.
t _{5is}	COM × SRC	Power of sales tax on commodity i, from source s, for government consumption.
t _{5_is}	1	Power of sales tax on commodity i, for government consumption.
t _{m_i}	COM	Power of import tax on commodity i.
t0rev	1	Total indirect tax revenues.

..... continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
t1rev_isj	1	Total indirect tax revenues from current production.
t2rev_isj	1	Total indirect tax revenues from capital formation.
t3rev_is	1	Total indirect tax revenues from item formation.
t4rev_i	1	Total indirect tax revenues from exports.
t5rev_is	1	Total indirect tax revenues from government.
tmrev_i	1	Total indirect import-tax revenues.
tycor _o	COR	Income tax rates for corporations.
tyhou _n	REG × INC	Income tax rates for households.
ucap _{jc}	CAP	Unemployed capital by type.
ulab _{jrp}	REG × PRF	Unemployed labour by profession and region.
ulnd _{jd}	LND	Unemployed land by type.
utility _m	REG × INC	Utility indices of households by region and household type.
x0 _{ij}	COM × IND	Output of commodity i, in industry j.
x0dom _i	COM	Total demand for domestic commodity i.
x0imp _i	COM	Total demand for imported commodity i.
x1 _{isj}	COM × SRC × IND	Demand for commodity i, from source s, in industry j for current production.
x1 _{sij}	IND	Demand for commodity i, on aggregate, in industry j for current production.
x1cap _{cj}	CAP × IND	Demand for capital by type in industry j, for current production.
x1cap _{cj}	IND	Demand for capital, on aggregate, in industry j for current production.
x1cap _{jc}	CAP	Total capital demand by type for current production.
x1cap _{cj}	1	Total capital demand for current production.

..... continued

Table 4.2 (continued)

Variable Name	Set/Sets name	Description of Variables
$x1lab_{rpj}$	$REG \times PRF \times IND$	Demand for labour by profession and region in industry j, for current production.
$x1lab_{rpj}$	IND	Demand for labour, on aggregate, in industry j for current production.
$x1lab_{rpj}$	1	Total labour demand.
$x1lnd_{dj}$	$LND \times IND$	Demand for land by type in industry j for current production.
$x1lnd_{dj}$	IND	Demand for land, on aggregate, in industry j for current production.
$x1lnd_{dj}$	1	Total capital demand in current production.
$x1lnd_{jd}$	LND	Total land demand by type for current production.
$x1mar_{isjm}$	$COM \times SRC \times IND \times MAR$	Demand for margin-good-m, for intermediate input good i, supplied from source s to industry j.
$x1oct_j$	IND	Units of "other costs" input in industry j for current production.
$x1prm_j$	IND	Indices of primary-factor demand, weighted by value-added, by industry for current production.
$x2_{isj}$	$COM \times SRC \times IND$	Demand for commodity i, from source s, in industry j for capital formation.
$x2_{sij}$	$COM \times IND$	Demand for commodity i, on aggregate, in industry j for capital formation.
$x2mar_{isjm}$	$COM \times SRC \times IND \times MAR$	Demand for margin-good-m, for intermediate good i, supplied from source s, to industry j for capital formation.
$x3_{is}$	$COM \times SRC$	Demand for commodity i, from source s, for item formation.
$x3item_{ism}$	$COM \times SRC \times MAR$	Demand for margin-good-m, for commodity i, supplied from source s for item formation.
$x3item_{kis}$	$ITM \times COM \times SRC$	Demand for commodity i, from source s, for item k formation.

..... continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
$x3_{item\_ski}$	ITM $\times$ COM	Demand for commodity i, on aggregate ,for item k formation.
$x4_i$	COM	Export-demand for commodity i.
$x4_{mar_{im}}$	COM $\times$ MAR	Demand for margin-good-m, to export commodity i.
$x5_{is}$	COM $\times$ SRC	Demand for commodity i, from source s, for government consumption.
$x5_{mar_{ism}}$	COM $\times$ SRC $\times$ MAR	Demand for margin-good-m, for commodity i, from source s for government consumption.
$xi2$	1	Capital goods price index.
$xi3$	1	Consumer goods price index.
$xi4$	1	Export goods price index.
$xi5$	1	Government-consumption goods price index for
$xifac$	1	Factor price index.
$xigdp$	1	GDP deflator.
$xiitem_m$	REG $\times$ INC	CPI by household type; by region and ihousehold type.
xim	1	Import price (CIF) index.
$ximp0$	1	Duty-paid import price index.
$xitem_{km}$	ITM $\times$ REG $\times$ INC	Demand for item k by household type; by region and household type.
$xitem_{mk}$	ITM	Aggregate household demand for item k.
y_j	IND	Investments in industry j.
$ycor_o$	COR	Income of Corporations .
$ycorcap_{oc}$	COR $\times$ CAP	Corporations' income from rental value of capital type. c
$ycorlnd_{od}$	COR $\times$ LND	Corporations' income from rental value of land type d.

... continued

Table 4.2 (continued)

Variable Name	Set/Sets Name	Description of Variables
ygov	1	Government income.
ygovcap _c	CAP	Government income from rental value of capital.
ygovcor _o	COR	Government income from income tax paid by corporations.
ygovhou _m	REG × INC	Government income from income tax paid by households.
ygovlnd _d	LND	Government income from rental value of land type d.
yhou _m	REG × INC	Income of household from region r and in household type n.
yhoucap _{mc}	REG × INC × CAP	Household income from rental value of capital type c.
yhoucor _{mo}	REG × INC × COR	Income from dividend paid by corporations to households from region r in household type n.
yhoud _m	REG × INC	Disposable income of households from region r in household type n.
yhoudr _m	REG × INC	Real disposable income of households.
yhougov _m	REG × INC	Household income from transfer payments (from government).
yhouhou _{mu_v}	REG × INC × REG × INC	Household income from transfer payments (from other households).
yhoulab _{mp}	REG × INC × PRF	Household income from wage earnings by profession.
yhoulnd _{md}	REG × INC × LND	Household income from rental value of land.
yhourow _m	REG × INC	Household income, from transfer payments (from ROW).
yrowcap _c	CAP	Income of ROW from rental value of capital employed in Pakistan.
yrowlnd _d	LND	Income of ROW from rental value of land in Pakistan.
z _j	IND	Output or activity index of industry j.

In the model there are coefficients which are computed from the data base, and parameters which are borrowed from other studies. For coefficients that are computed from the data base, we have given their formulas within the equations. We make use of the names of data matrices shown in Figure 4.3 to 4.7, 4.27, and 4.28 to define the formulas for the computation of these coefficients. To represent an aggregation of a matrix over a subscript, we append an underscore '_' along with that subscript. For example, the three-dimensional matrix $YHOUCAP_{mc}$ (which contains household income from different types of capital in the base year) when aggregated over subscript c is given the name of $YHOUCAP_{cmc}$ (which represents the aggregation of household capital income by all types), *i.e.*,

$$YHOUCAP_{cmc} = \sum_{c \in CAP} YHOUCAP_{mc}.$$

All the names of data matrices are given in upper-case. Nevertheless, there are some coefficients which are not computed within the equations. Table 4.3 lists all these coefficients' names and their definitions.

All parameters' names are also in upper-case, and begin with the Greek letter ' σ '. They are used to represent the elasticity of substitution. The letter is followed by set or subset names to give elasticity of substitution between elements of that set or subsets. For example, ' σFAC ' gives the elasticity of substitution between factors of production given in the set FAC . The list of parameters is given in Table 4.3. In Chapter 5 we explain how the value to each of these parameters is assigned.

Table 4.3 Parameters and Coefficients of the Model

Equation	Coefficient [@] or Parameter	Description
(1.1)	σPRF_{rj}	Elasticity of substitution between skilled and unskilled labour from region r, in industry j.
(3.1)	$\sigma COM1_i$	Elasticity of substitution between domestic and foreign sources of intermediate input i for current production.
(4.1) to (4.3)	σFAC_j	Elasticity of substitution between primary factors in industry j.
(6.1)	σOUT_j	Elasticity of transformation between output-goods in industry j.
(7.1)	$\sigma IELEL$	Elasticity of substitution between electricity supply from two less-flexible electricity industries (Steam and Combined cycle).
(7.3)	$\sigma IELEM$	Elasticity of substitution between electricity supply from two more-flexible electricity industries (Hydro and Gas turbine).
(7.5) to (7.6)	$\sigma IELE$	Elasticity of substitution between electricity supply from low-flexible and high-flexible electricity industries.
(8.1)	$\sigma COM2_i$	Elasticity of substitution between domestic and foreign sources of good i for capital formation.
(9.1) to (9.2)	$ALPHA_{I_{km}}$	Share of supernumerary expenditure on item k in household type n in region r.
(9.3)	$ALPHA_m$	Share of supernumerary expenditure in total expenditure of household type n in region r.
(9.1)	EPS_{km}	Expenditure elasticity of item k for household type n in region r.

[@] Coefficients other than data matrices are listed in this Table.

... continued

Table 4.3 (continued)

Equation	Coefficient or Parameter	Description
(9.2)	FRISCH _m	Reciprocal of share of supernumerary expenditure in total expenditure of household type n in region r.
(9.3)	DELTA _{km}	Marginal-expenditure-share of item k in total expenditure on item k of household type n in region r.
(11.4)	σ COM3 _i	Elasticity of substitution between domestic and foreign sources of good i for item formation.
(12.1)	EXP_ELAST _i	Export elasticity of commodity i.
(21.1)	QCOEF _j	Ratio of gross (before depreciation) to the net (after depreciation) rate of return in industry j.
(21.2)	BETA_R _j	Elasticity of expected rate-of-return on capital in industry j, with respect to an increase in the planned stock of capital in industry j.
(21.3)	INV_ELAST _j	Elasticity of capital stock in industry j with respect to investment in industry j.
(25.1)	σ REG _p	Elasticity of inter-region migration of household with profession p.

4.7 Equation System

The equations of the model are organised into 31 blocks. In Section 4.9 to 4.40 we discuss the percentage-change form of equations in each block and their underlying theory, or assumption behind them. In each section we define the relevant variables and the coefficients used in the equation set. Except where indicated, the variables are percentage changes and are in lower-case characters.

The equations of the model are distributed into the following 31 blocks:

- (1) demand for labour by region and profession;
- (2) demand for capital and land by type;

- (3) demand for intermediate inputs by source;
- (4) demand for three composite primary factors;
- (5) demand for "other costs", composite intermediate inputs and all-primary-factor input;
- (6) supply of commodities by industries and domestic supply on aggregate; except of electricity;
- (7) electricity supply structure;
- (8) demand for investment goods;
- (9) coefficients in households' demand equation;
- (10) households' demand for consumption items;
- (11) commodities' demand for item formation;
- (12) commodities' demand for export and government consumption;
- (13) demand for margin-goods;
- (14) purchaser prices;
- (15) various form of indirect taxes;
- (16) implicit tax rate for commodities with regulated prices;
- (17) market-clearing equations for commodities;
- (18) demand for factors aggregate;
- (19) aggregate demand for final consumption, investments, exports, imports and indirect tax revenues;
- (20) GDP from income and expenditure side and the balance of trade;
- (21) allocation of total investment to industries;
- (22) various price indices;
- (23) factor-price indices for income mapping;
- (24) factors-market clearing;
- (25) rural-urban migration and real wages;
- (26) factor-endowments of institutions;
- (27) income of institutions by source;
- (28) income of institutions;
- (29) households' expenditure and disposable income;
- (30) Gross National Products (GNP) and the balance of payments; and

(31) savings of domestic institutions.

As mentioned, GE-PAK is in the spirit of ORANI. To describe the equations of GE-PAK, we follow Horridge's exposition for ORANI-F (an extended version of ORANI) given in the most recent document of the model (Horridge, Parmenter and Pearson; 1993).

4.8 Structure of Production

The model allows each industry to produce several commodities, using as inputs: domestic and imported commodities; several types of land, labour, and capital; and 'other costs'. The multi-input and multi-output production specifications are kept manageable by a series of separability assumptions illustrated by the nesting shown in Figure 4.8. The assumption of input-output separability implies that the generalised production function for each industry:

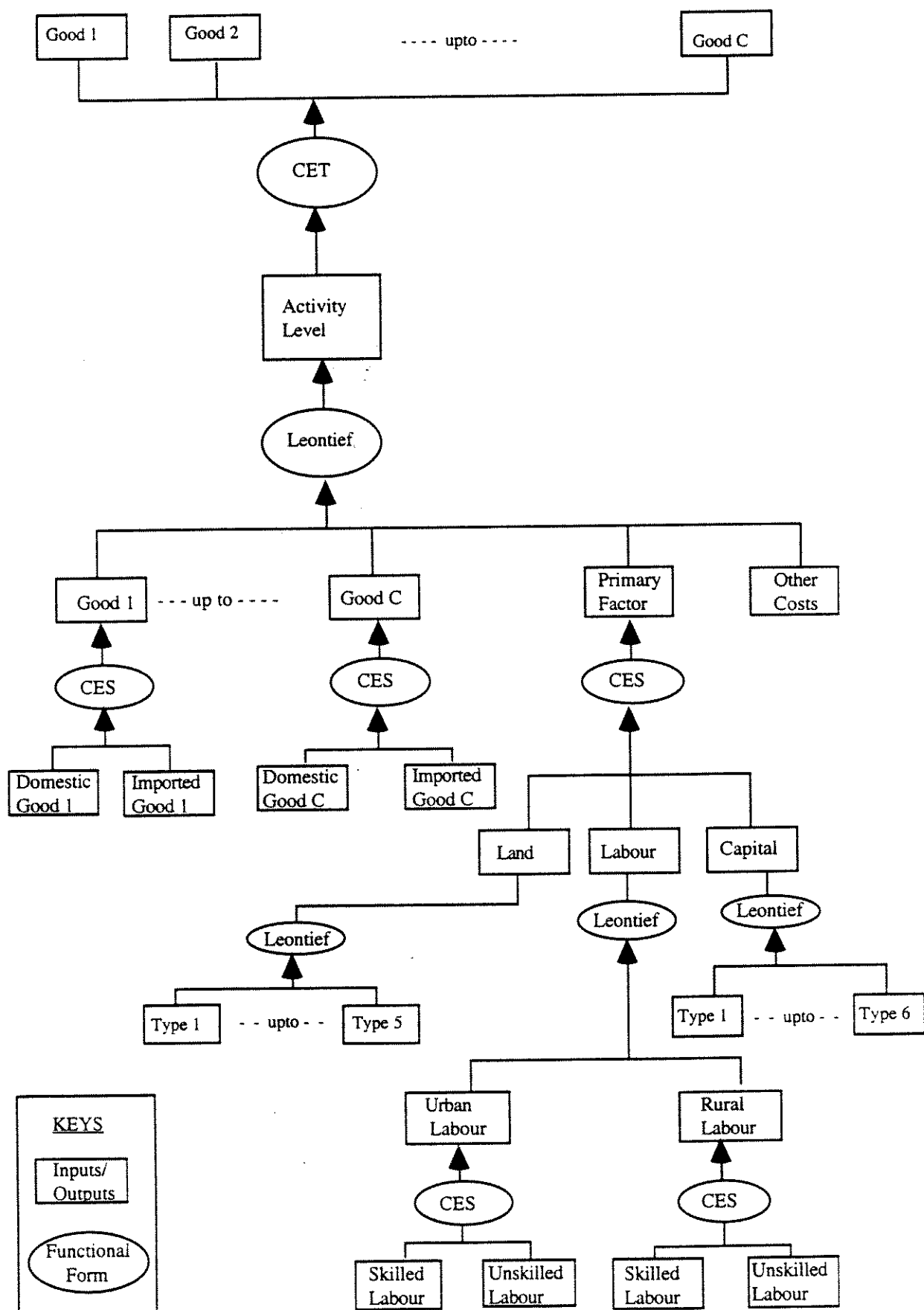
$$F(\text{inputs}, \text{outputs}) = 0, \quad (4.8.1)$$

may be written as

$$G(\text{inputs}) = Z = H(\text{outputs}), \quad (4.8.2)$$

where Z is an index of industry's activity. This assumption reduces the number of estimated parameters required by the model. Figure 4.8 shows that the H function in (4.8.2) is derived from a constant elasticity of transformation (CET) aggregation function while the G function is broken into a sequence of nests. At the top level, a Leontief production function combines commodity composites, a primary factor composite, and 'other costs'. Consequently they are all demanded in direct proportion to Z . Each commodity composite is a CES function of a domestic good and the imported equivalent. The primary-factor composite is a CES aggregation of composite land, composite capital and composite labour. The composite labour is a Leontief aggregation of composite urban labour and composite rural labour. The composite labour in each region, *i.e.* urban and rural, is a CES aggregation of skilled and unskilled labour. The composite capital is a Leontief aggregation of six types of capital while the composite land is a Leontief aggregation of five types of land.

Figure 4.8 Current Production Structure



All industries share this common production structure. However, for a group of industries, primary factors are combined with intermediate inputs using a CES production function to allow energy-factor and inter-energy substitution. We have described these production functions as special cases of the default production structure.

In Sections 4.9 to 4.13 we discuss all the equations of the default current production structure and then proceed to the additional equations defined for the special cases in Section 4.14. To discuss the equations of the default production structure, we begin at the bottom of Figure 4.8 and work upwards.

4.9 Demand for Labour by Profession and Region

The data on the labour force and households in Pakistan can be broadly categorised by rural and urban regions. All villages and small towns are grouped in the rural region while big cities are included in the urban region. However, the data on industries is not given by region. The labour employment in industries shows that each industry employs four categories of labour. Figure 4.9 is a schematic representation of the model's 2×2 matrix of labour employment in industry j . The columns in Figure 4.9 identify two professions (skilled and unskilled) while the two rows show the urban and the rural regions. The three-dimensional wage-bill matrix, $V1LAB_{rpj}$, contains labour wages by industry, region and profession.

Figure 4.9 Labour Categories in Industries

Region	Professions	
	Skilled	Unskilled
Rural	$V1LAB_{rural,skilled,j}$	$V1LAB_{rural,unskilled,j}$
Urban	$V1LAB_{urban,skilled,j}$	$V1LAB_{urban,unskilled,j}$

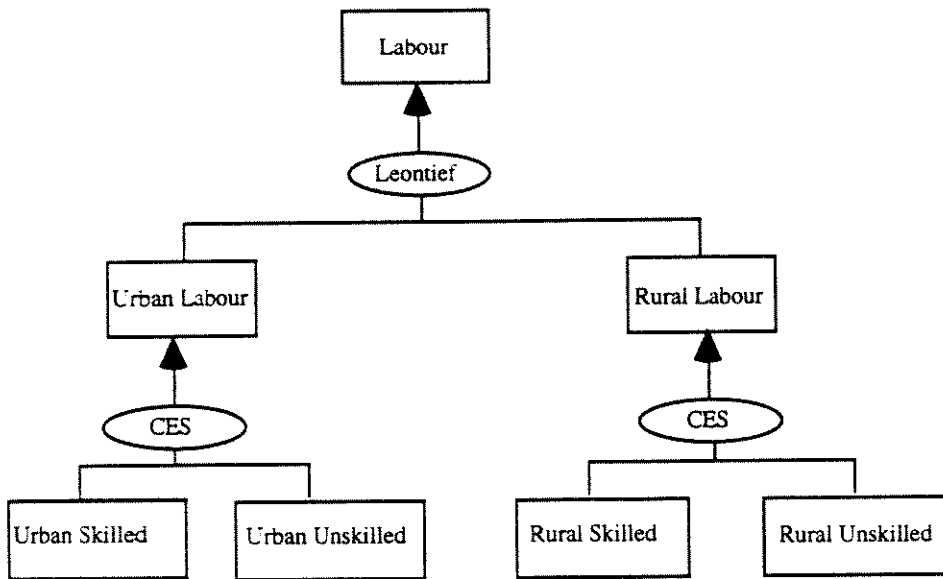
The wage bill pattern in the base year data shows that:

- 95 per cent of the total labour employed in the agricultural industries is rural;

- 100 per cent of the total labour employed in the large-scale manufacturing industries is urban; and
- in all other industries the share of rural labour varies from 20 to 55 per cent.

The above employment pattern implies that agricultural industries are concentrated in the rural region, large-scale manufacturing industries are concentrated in the urban region, and all other industries are spread across the two regions. In our model we assume that this pattern of industries location remains constant over the simulation period. Therefore, we assume that labour employment in an industry is a Leontief composite of rural and urban labour, and the substitution possibility in labour demand within an industry is only between skilled and unskilled labour available within a region. We assume that the region-specific labour composite input is a CES aggregation of profession types in a region. Figure 4.10 shows this labour demand structure which is common to all industries.

Figure 4.10 Labour Demand Structure



The top level nest of labour demand shows that composite labour demand in an industry is a Leontief composition of labour from rural and urban regions while the bottom level nests show CES aggregation of profession types in region-specific labour input demands.

Block 1 Equations for region-profession specific labour demand

$$x1lab_{rpj} = x1lab_{rpj} + allab_{pj} + allab_{rpj} - \sigma_{PRF_{rj}} [(p1lab_{rpj} + allab_{rpj}) - p1lab_{pj}],$$

$$r \in REG, p \in PRF, j \in IND, (1.1)$$

$$p1lab_{pj} = \frac{1}{V1LAB_{pj}} \sum_{p \in PRF} \{V1LAB_{rpj} \times (p1lab_{rpj} + allab_{rpj})\},$$

$$r \in REG, j \in IND, (1.2)$$

$$p1lab_{rpj} = \frac{1}{V1LAB_{rpj}} \sum_{r \in REG} V1LAB_{rpj} \times (p1lab_{rpj} + allab_{rpj}),$$

$$j \in IND. (1.3)$$

Block 1 (above) contains the equations corresponding to the nesting structure of Figure 4.10. For industry j , the equations for (say) rural-labour demand by professions are derived from the following optimisation problem.

Choose inputs of labour by profession from rural labour,

$$X1LAB_{rpj}, \quad r = \text{rural}, p \in PRF, (4.9.1)$$

to minimise total rural labour cost,

$$\sum_{p \in PRF} \{P1LAB_{rpj} \times X1LAB_{rpj}\}, \quad r = \text{rural}, (4.9.2)$$

where

$$X1LAB_{rpj} = CES \left(\frac{X1LAB_{rpj}}{A1LAB_{rpj}} \right), \quad r = \text{rural}, p \in PRF, (4.9.3)$$

regarding as exogenous to the problem

$$P1LAB_{rpj} \text{ and } X1LAB_{rpj}, \quad r = \text{rural}, p \in PRF. (4.9.4)$$

The solution to the problem in percentage-change form (see Appendix A for the derivation) is given by

$$x1lab_{rpj} = x1lab_{rpj} + allab_{rpj} - \sigma_{PRF_{rj}} [(p1lab_{rpj} + allab_{rpj}) - p1lab_{pj}],$$

$$r = \text{rural}, j \in IND, (4.9.5)$$

$$p1lab_{pj} = \frac{1}{V1LAB_{pj}} \sum_{p \in PRF} \{V1LAB_{rpj} \times (p1lab_{rpj} + allab_{rpj})\},$$

$$r \in REG, j \in IND. (4.9.6)$$

In equations (4.9.5), $allab_{rpj}$, are region-and-profession specific labour-saving technical changes in industry j . Equations (4.9.5) state that demands for rural labour by profession type are proportional to: overall rural labour demand; profession-specific rural-labour-augmenting technical changes; and a price term. The price term is composed of an elasticity of substitution, $\sigma_{PRF_{rj}}$, multiplied by the percentage change in a price ratio representing the effective wage of profession category p relative to the overall wage for rural labour, $p_{llab\_p_{rj}}$, when $r=rural$. The parameter, $\sigma_{PRF_{rj}}$, is the elasticity of substitution between professions of labour from region r in industry j . Changes in the relative prices of rural labour, of two professions, induce substitution in favour of relatively cheapening profession. The effective wage term, $\{p_{llab_{rpj}} + allab_{rpj}\}$, accounts for the effect of technical change. For example, the region-profession specific labour augmenting technical change in industry j at the rate of 1 per cent, *i.e.*,

$$allab_{rpj} = -1,$$

will reduce the nominal wages for this labour type effectively by 1 per cent. The overall wage of rural labour, defined in equation (4.9.6), is a cost weighted average of wages of rural labour by professions.

The second nest at the bottom of Figure 4.10 shows the demand structure of urban labour; it is similar to that for rural labour. Hence we can derive the profession-specific urban labour demands using the procedure applied for the rural labour demand discussed in the above paragraph. The equations (4.9.1) to (4.9.6) are repeated with $r = urban$.

As shown by the top-level nest of labour demand structure in Figure 4.10, the total labour demand in industry j , ($X1LAB_{rpj}$), is a Leontief composite of rural and urban labour given by:

$$X1LAB_{rpj} = \text{MIN} \left(\frac{X1LAB_{p_{ri}}}{A1LAB_{p_{rj}}} \right) \quad r \in \text{REG}, j \in \text{IND. (4.9.7)}$$

Consequently, labour demand by region ($X1LAB_{p_{rj}}$) is in direct proportion to the overall labour demand of industry j . The Leontief production function is

equivalent to a CES production function with substitution elasticity set to zero. Hence, the derived region-specific labour demand equations (4.9.8) resemble those derived from the CES case but lack price (substitution) terms.

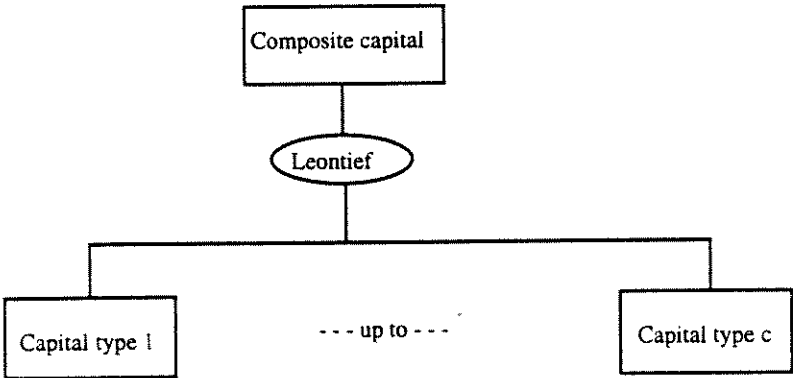
$$x1lab_{pj} = x1lab_{rpj} + a1lab_{pj}, \qquad r \in REG \text{ and } j \in IND. \quad (4.9.8)$$

By replacing $x1lab_{pj}$ (region-specific labour demand in industry j) in equations (4.9.5) with $x1lab_{pj}$ defined in equation (4.9.8), we arrived at the labour demand equations given in Block 1.

Equation (1.3) in Block 1 defines the average cost of labour in industry j , which is again a cost weighted index of the effective unit-cost of rural and urban labour. This average price of labour is used to determine composite labour demand in industry j , defined in equation (2.2); given in Block 2.

4.10 Demand for Capital and Land by Type

Figure 4.11 Capital Demand Structure



In the model there are six types of capital, identified in set CAP and five types of land, defined in set LND. The categories of capital and land are based on ownership of these factors which is assumed to be given exogenously. We assume that the capital demand in an industry is a Leontief composition of the six types of capital. Figure 4.11 shows the structure for capital demand in industry j . A similar structure is assumed for five types of land. The Leontief production function is equivalent to a CES production function with the substitution elasticity set to zero. Hence, the derived demand equations (2.1)

resemble that derived from the CES case (Appendix A); except that it lacks price terms.

Block 2 Demand equations for capital and land by type

$$x_{lcap_{cj}} = x_{lcap\_c_j}, \quad c \in CAP, j \in IND, \quad (2.1)$$

$$p_{lcap_{cj}} = p_{lcap\_c_j}, \quad c \in CAP, j \in IND, \quad (2.2)$$

$$x_{llnd_{dj}} = x_{llnd\_d_j}, \quad d \in LND, j \in IND, \quad (2.3)$$

$$p_{llnd_{dj}} = p_{llnd\_d_j}, \quad d \in LND, j \in IND. \quad (2.4)$$

Due to the Leontief production function, the demand for each type of capital in industry j ($x_{lcap_{cj}}$) changes in direct proportion to the total demand for capital as shown in equation (2.1). We assume that the six types of capital, identified by the source of supply, are homogenous and, hence, the price of capital for each type in industry j ($p_{lcap_{cj}}$) changes in direct proportion to the price of aggregate capital in industry. The demand for land in each industry is also a Leontief composite of the five types of land. Hence the derived demand equations for five types of land in Block 2 resemble that for capital.

The disaggregation of capital and land by types is important for income mapping. Each type of capital and land has a certain distribution pattern across industries. Hence, the prices of capital by type when aggregated over industries, *i.e.* $p_{lcap\_j_c}$, are not uniform as the rental value of capital is not uniform across industries. The price of capital by type for each industry plays an intermediary role in allocation of factors' returns to institutions.

4.11 Demand for Intermediate Inputs by Source

Following Armington (1969, 1970) we assume that imports are imperfect substitutes for domestic supplies. Block 3 (below) covers equations determining the import and domestic mix for intermediate-commodity demands.

Block 3 Equations for intermediate input demand by source and industries

$$x1_{isj} = x1_{sij} + a1_{isj} - \sigma COM1_i [(p1_{isj} + a1_{isj}) - p1_{sij}],$$

$$i \in COM, s \in SRC, j \in IND, (3.1)$$

$$p1_{sij} = \frac{1}{V1BAS_{sij}} \sum_{s \in SRC} V1BAS_{isj} (p1_{isj} + a1_{isj}),$$

$$i \in COM, j \in IND. (3.2)$$

Figure 4.12 Structure of Intermediate Input Demand by Source

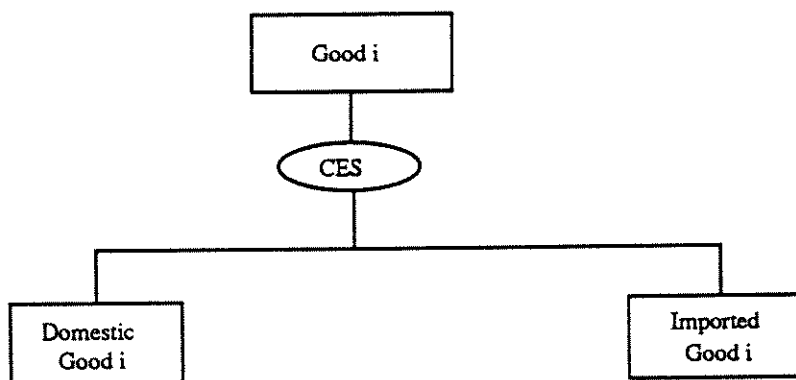


Figure 4.12 shows that in industry j , the intermediate input commodity i is a CES composite of commodity i from the two sources, *i.e.*,

$$X1_{sij} = CES_{s \in SRC} \left(\frac{X1_{isj}}{A1_{isj}} \right),$$

$$i \in COM, j \in IND. (4.11.1)$$

The total cost of imported and domestic commodity i is minimised subject to the production function given in equation (4.11.1). Following the derivation procedure given in Appendix A, we arrived at equations for intermediate commodity demand from each source. These are given in Block 4. The demand for intermediate commodity i from each source is proportional to the index of effective composite commodity i demand (quantities), $x1_{sij}$, and to a price term. The index of quantities (defined in Block 5) represents the total demand for commodity i by industry j . The variable of technical-change $a1_{isj}$ is specific to industry, commodity, and source. As shown in equation (3.1), the price terms consist of an elasticity of substitution, $\sigma COM1_i$,

multiplied by the percentage change in a ratio representing the effective cost of commodity i by source, relative to the effective-cost index of the import and domestic prices. Lowering a source-specific price, relative to the average, induces substitution in favour of that source. The average effective-cost index, pl_{sij} , is again a cost-weighted index of individual prices and technical changes. Equation (3.2) defines the commodity-cost index. The coefficient, $VIBAS1_{isj}$, is the matrix of data flows on basic value of intermediate inputs used by industry j from the two sources (see Figure 4.3 on the input-output data base).

4.12 Demand for Land, Labour and Capital by Industries

In each industry there are 6 types of capital, 5 types of land and 4 types of labour. The demand for each type of labour, capital and land is determined by their assumed demand structures. In Section 4.9 and 4.10 we have described these structures and the corresponding equations. As shown in Figure 4.13, total primary factor demand in an industry is a CES composite of capital, land and labour demand. Block 4 (below) contains equations determining demand for the three primary factors: composite capital; composite land; and composite labour.

Block 4 Demand equations for Land, Labour and Capital

$$x1cap\_c_j = x1prm_j + alcap\_c_j - \sigma FAC_j [\{plcap\_c_j + alcap\_c_j\} - plprm_j],$$

$$j \in IND, (4.1)$$

$$x1lab\_rp_j = x1prm_j + allab\_rp_j - \sigma FAC_j [\{plab\_rp_j + allab\_rp_j\} - plprm_j],$$

$$j \in IND, (4.2)$$

$$x1lnd\_d_j = x1prm_j + allnd\_d_j - \sigma FAC_j [\{pllnd\_d_j + allnd\_d_j\} - plprm_j],$$

$$j \in IND, (4.3)$$

$$plprm_j = \frac{1}{V1PRM_j} \left(V1CAP\_c_j \times \{plcap\_c_j + alcap\_c_j + alprm_j\} \right. \\ \left. + V1LND\_d_j \times \{pllnd\_d_j + allnd\_d_j + alprm_j\} \right. \\ \left. + V1LAB\_rp_j \times \{pllab\_rp_j + allab\_rp_j + alprm_j\} \right),$$

$$j \in IND. (4.4)$$

Their derivation follows a pattern similar to that discussed for the derivation of source-specific intermediate input demands in the previous section. In this case, total primary factor cost is minimised subject to the production function

$$X1PRM_j = CES \left(\frac{X1LAB\_rpj}{A1LAB\_rpj}, \frac{X1CAP\_cj}{A1CAP\_cj}, \frac{X1LND\_dj}{A1LND\_dj} \right), \quad j \in IND. (4.12.1)$$

The coefficients, $A1CAP\_cj$, $A1LND\_dj$, and $A1LAB\_rpj$ are factor-saving technical changes in industry j for capital, land and composite labour (uniform for each profession and region type) respectively. The solution to the problem in percentage-change form is given by equations (4.1) to (4.3) in Block 4 (see Appendix A for derivation). The demand for each factor is proportional to overall factor demand, $x1prm_j$, to a technical-change term, and to a price term. The price term consists of an elasticity of substitution for primary factors, σFAC_j , multiplied by the ratio representing effective unit cost of the factor to the overall primary factor costs $p1prm_j$. The effective unit-cost of a factor is the price of the factor plus the factor-saving technical change. Changes in the relative effective unit cost induce substitution in favour of relatively cheapening factors. The average-effective cost of primary-factor inputs, $p1prm_j$, given in equation (4.4), is again a cost-weighted index of individual factor prices and their technical-change terms. In equations (4.4); $V1LAB\_rpj$, $V1CAP\_cj$, and $V1LND\_dj$ are the cost of composite labour, capital and land costs in industry j , respectively.

4.13 Demand for Composite Primary Factors and Intermediate Inputs in Current Production

The objective of this section is to explain the input structure of industries and to derive the equations for composite primary factor and intermediate inputs demand. In energy-economy interaction models for developing countries, various input structures have been assumed which incorporate inter-energy and factor-energy substitutions. For the 128 industries in our model we have defined five types of input structure (each for a set of

industries or for a specific industry). Each production-structure type has a specific pattern of inter-energy or energy-factor substitution. However, there is one input structure for all those industries in which energy is used as one of the intermediate inputs. We first discuss this default input structure, given in Figure 4.13 before discussing the five industry-specific structures. Figure 4.13 shows an abstract form of Figure 4.8 given in Section 4.8.

The top most nest of input-demand in Figure 4.13 shows that the commodity-composite, the primary factors-composite, and 'other cost' inputs are combined using a Leontief production function given by

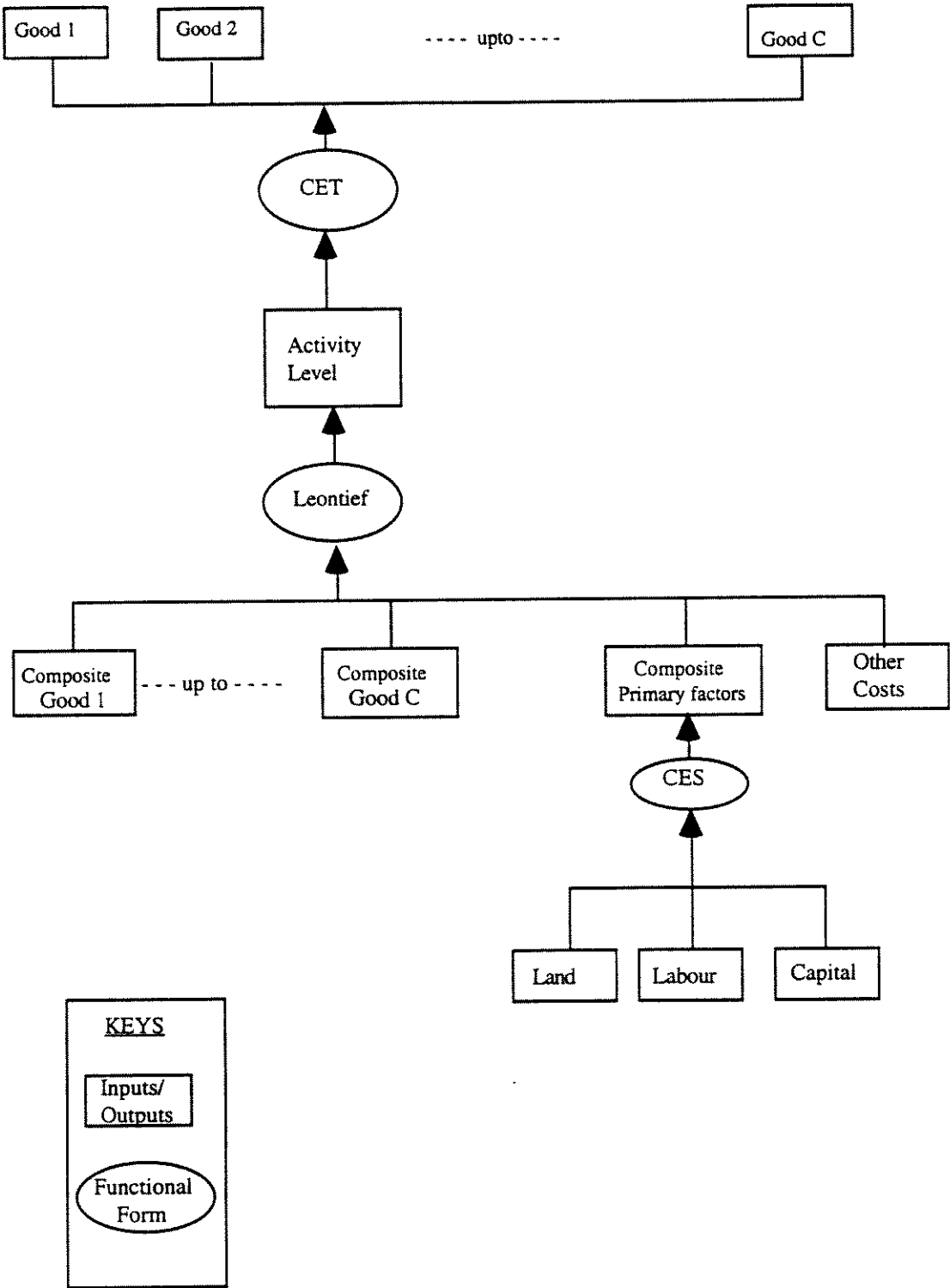
$$Z_j = \frac{1}{A1TOT_j} \min_{i \in COM} \left[\frac{X1_{-}s_{ij}}{A1_{-}s_{ij}}, \frac{X1PRM_i}{A1PRM_j}, \frac{X1OCT_i}{A1OCT_j} \right], \quad j \in IND. \quad (4.13.1)$$

Consequently, each of these three categories of inputs identified at the top level is demanded in direct proportion to Z_j . The variable Z_j is the output level in all industries with a single output, and is an activity index in the multiple-output industries. The equations determining output composition in multiple-output industries are discussed in Section 4.15.

The Leontief production function in equation (4.13.1) is equivalent to a CES production function with the substitution elasticity set to zero. Hence, the derived demand equations in Block 5 resemble those derived from a CES case (Appendix A) but lack price terms.

In Equations (5.1) to (5.5) in Block 5 (next page), there are 2 types of technical-change variables. The technical change variables $altot_j$ represent a Hicks-neutral technical change affecting all inputs equally in industry j , while $aloc_tj$, $alprm_j$, and $al_{-}s_{ij}$ are input-specific technical-change variables. Equations (5.1) to (5.3) state that the three composite inputs (primary-factor composite, intermediate-inputs composite, and "other costs") are demanded by industry j in proportion to its output or activity level and two technical-change variables.

Figure 4.13 Current Production Structure



Block 5 Composite-inputs demand equations

$$x_{loct_j} = a_{tot_j} + a_{loct_j} + z_j, \quad j \in IND, (5.1)$$

$$x_{lprm_j} = a_{tot_j} + a_{lprm_j} + z_j, \quad j \in IND, (5.2)$$

$$x_{l_{s_{ij}}} = a_{tot_j} + a_{l_{s_j}} + z_j, \quad i \in COM, j \in IND, (5.3)$$

$$p_{0ind_j} - a_j = \frac{1}{COSTS_j} \left(\sum_{i \in COM} \sum_{s \in SRC} PUR_{l_{isj}} \times p_{l_{isj}} \right. \\ \left. + \sum_{r \in REG} \sum_{p \in PRF} VILAB_{rpj} \times p_{l_{lab_{rpj}}} \right. \\ \left. + V1CAP_{c_j} \times p_{l_{cap_{c_j}}} \right. \\ \left. + V1LND_{d_j} \times p_{l_{lnd_{d_j}}} + V1OCT_j \times p_{loct_j} \right), \\ j \in IND, (5.4)$$

$$a_j - a_{tot_j} = \sum_{i \in COM} (PUR_{l_{s_j}} \times a_{l_{s_j}} + \sum_{s \in SRC} PUR_{l_{isj}} \times a_{l_{isj}}) \\ + V1PRM_j \times a_{lprm_j} + \sum_{r \in REG} \sum_{p \in PRF} VILAB_{rpj} \times a_{l_{lab_{rpj}}} \\ + LAB_{rpj} \times a_{l_{lab_{rpj}}} + V1CAP_{c_j} \times a_{l_{cap_{c_j}}} + V1LND_{d_j} \times a_{l_{lnd_{d_j}}} \\ + V1OCT_j \times a_{loct_j}, \quad j \in IND, (5.5)$$

$$p_{loct_j} = xi3 + f_{loct_j}, \quad j \in IND. (5.6)$$

Equation (5.4) defines the effective price per unit of output (or activity) in industry j (p_{0ind_j}) as cost-share-weighted averages of input prices. Given the constant returns to scale, which characterise the model's production technology, these cost-share-weighted averages of input prices define average costs. Setting output prices equal to average costs imposes the competitive zero-pure profit condition. In equations (5.4), the variable a_j is an index of all technical-change variables which represents the effects of technical progress for all types of input used in industry j . This cost-weighted average index is defined in equation (5.5). Equation (5.6) states that price of 'other costs' input is in direct proportion to CPI ($xi3$). The variable 'floct' represents an exogenous shift in the price of 'other costs' input.

4.14 Energy-Factor and Inter-energy Substitutions in Current Production

In energy-economy interaction models for developing countries various input structures have been assumed which incorporate inter-energy and factor-energy substitutions.

In a general equilibrium model for developing countries, Blitzer (1986) assumes energy to be a substitute for capital and labour. In his model there are two production sectors: rural and urban. Capital, labour and energy are substitutes in a Cobb-Douglas production function in the two sectors. The same specification is applied by Blitzer (1984) in the energy-economy interaction model for Jordan.

In the energy-economy interaction model for Sri Lanka, Blitzer and Eckaus (1985) define four types of production structures corresponding to the four categories of sectors: tree crop & manufacturing, transport, electricity, and oil refinery.

- In the tree crop and manufacturing sectors, capital and labour are substitutes at the margin in a Cobb-Douglas production function, while the Leontief production function combines energy with installed capital. Energy in these sectors is a Cobb-Douglas composite of petroleum products and traditional fuels.
- In the transport sector, petroleum products and capital stock are substitutes in a Cobb-Douglas production function while the Leontief production function combines the energy-capital composite input with labour and all other intermediate inputs.
- In the refinery sector the Leontief production function combines labour with capital and all intermediate inputs.
- In the electricity sector, the model minimises thermal electricity generation subject to the two constraints: First, the total electricity supply should be equal to its total demand. Second the hydro electricity supply is determined by the fixed capital-output ratio applied to the installed capital in the hydro electricity sector.

The inter-fuel and energy-capital substitution nests have been incorporated in the ORANI-FH application (Industry Commission, 1991) to estimate the costs and benefits of reducing greenhouse gas emissions for Australia. In this application all industries have a uniform production function. At the bottom level, "capital-land" is a CES composite of capital and land while "energy" is a CES composite of all types of energy products used in the industry. At the middle level, the "capital-energy" bundle is defined as a CES composition of energy and the capital-land composite input. The "capital-energy" bundle is then assumed to be a substitute for effective labour in a CES function. At the top level the Leontief production function combines non-energy commodities and "other costs" inputs with the composite input of "factor-energy" bundle.

A variety of inter-energy and energy-capital substitution pattern is found in the energy-economy models for developed countries. For example, Bergman's MSG-4 model¹ incorporates substitution possibilities between capital, labour, an aggregated energy input, and an aggregated material input. The aggregated energy input is defined as an aggregate of electricity and fuels. The substitution responses are formally represented by generalised Leontief cost functions, interpreted as second-order approximation to the underlying production structure (Diewert, 1971).

Our survey of inter-relationships of energy inputs and other inputs in production shows that energy is treated as a substitute for capital, or capital-land composite, or primary-factor composite in most of the models. For some disaggregated production sectors, various inter-fuel substitution patterns are incorporated according to the fuel-consumption pattern in these sectors.

¹ A complete description of MSG-4 is given in Longva, Lorentsen, and Olsen (1985).

In GE-PAK, we have defined five types of input structure that have some industry specific energy-factor and inter-energy substitution. Figures 4.14 to 4.18 show these input structures which correspond to:

- agricultural industries;
- manufacturing (both large and small-scale), mining, and construction industries;
- road transport industry;
- combined cycle electricity industry; and
- steam electricity industry.

These five input-structures are similar to the default production structure (given in Figure 4.8 and discussed in Section 4.8 to 4.13) except for inter-energy and factor-energy substitution nests. For example, in all industries the "effective labour" input is defined by a two-level nested function of four types of labour. Similarly, the "effective commodity" input is also defined as a CES aggregate of the commodity supply from two sources; domestic and imported. These six types of input structure incorporating different inter-energy or factor-energy substitutions are defined in line with the pattern of energy consumption in the corresponding sectors in Pakistan.

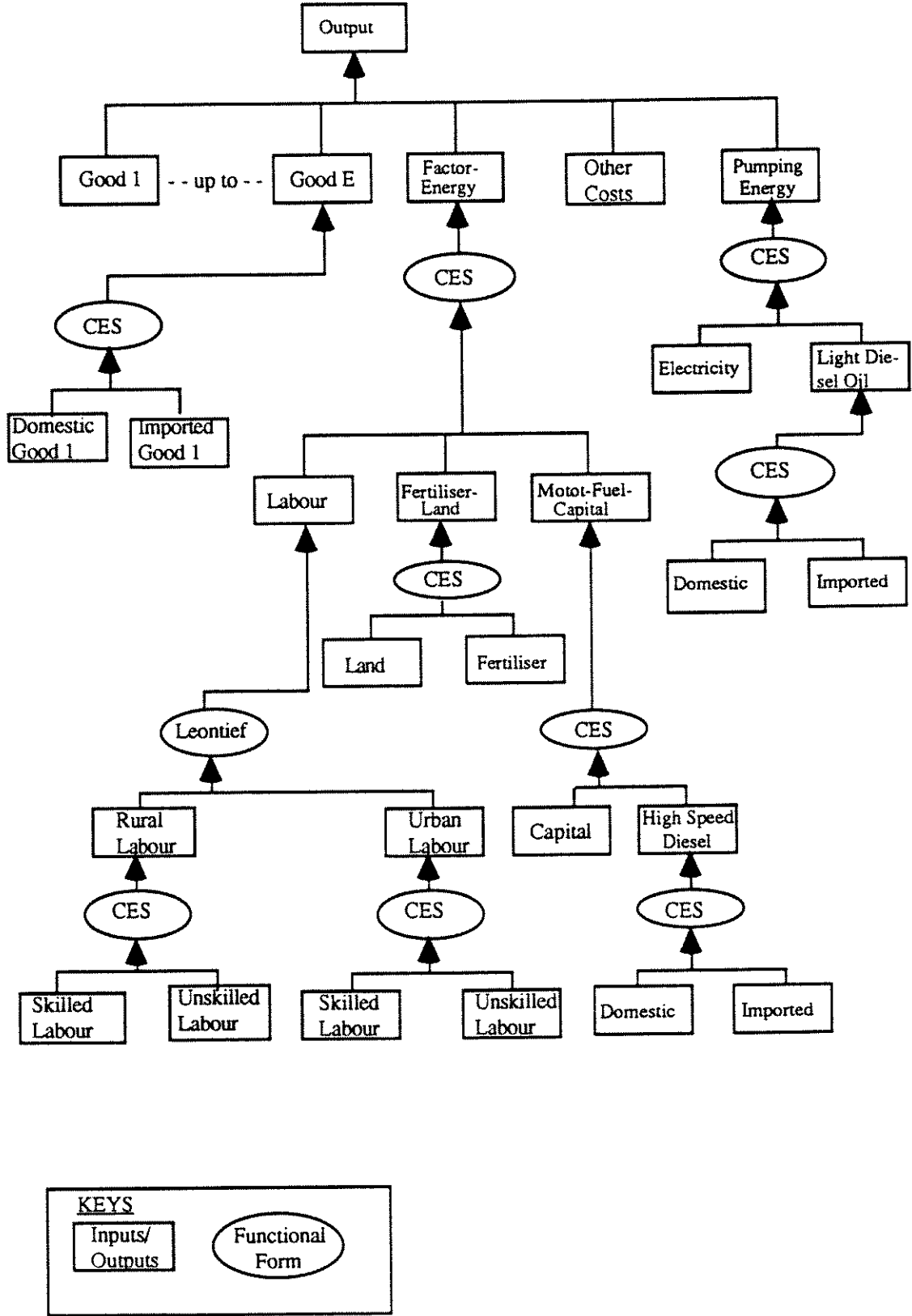
Since these input structures are more elaborate versions of the default structure discussed in the above sections, we have defined a new equation for each new variable introduced in the following sub-sections. Hence in our list of variables in Table 4.2, we have not included all the new variables defined in these sub-sections. Similarly, equations corresponding to these variables are also not counted in the number of equations. In the following subsections we derive equations for the input structures shown in Figures 4.14 to 4.18.

4.14.1 Input Structure for Agricultural Industries

Figure 4.14 shows the assumed input structure of agricultural industries. Among the inputs of the agricultural industries in Pakistan, there are two commercial energy products: two petroleum products, and one energy-intensive input: chemical fertiliser. High speed diesel is used to run tractors

and accessories while light diesel oil is used for underground water pumping. In the agricultural industries the capital stock mainly represents tractors and accessories, hence, consumption of high speed diesel depends on the stock of equipment, their usage and their fuel intensities. We define the "motor fuel-capital" as a CES composite of high speed diesel and capital. For fertiliser our assumption is that its consumption is related to the usage of land. We assume that "fertiliser-land" is a CES composite of land and fertiliser. As shown in Figure 4.14, "motor-fuel- capital", "fertiliser-land" and "effective labour" are assumed to be substitutes in a CES production function.

Figure 4.14 Input Structure for the Agricultural Industries



The following set of equations define the demand for primary factors, fertiliser and energy products represented in the nested-production structure given in Figure 4.14.

$$x1lnd\_dj = x1lndfjt_j + a1lnd\_dj + alprm_j - \sigma AGR1(\{p1lnd\_dj + a1lnd\_dj + alprm_j\} - p1lndfjt_j),$$

$$j \in IAGR, (4.14.1.1^{\frac{1}{2}})$$

$$x1\_sij = x1lndfjt_j + a1\_sij - \sigma AGR1(\{p1\_sij + a1\_sij\} - p1lndfjt_j),$$

$$i = \text{fertiliser}, j \in IAGR, (4.14.1.2^{\frac{1}{2}})$$

$$p1lndfjt_j = \frac{1}{PUR1\_sij + V1LND\_dj} (PUR1\_sij \times \{p1\_sij + a1\_sij\} + V1LND\_dj \times \{p1lnd\_dj + a1lnd\_dj + alprm_j\}),$$

$$i = \text{fertiliser}, j \in IAGR, (4.14.1.3)$$

$$x1cap\_cj = x1caphsdj + a1cap\_cj + alprm_j - \sigma AGR2(\{p1cap\_cj + a1cap\_cj + alprm_j\} - p1caphsdj),$$

$$j \in IAGR, (4.14.1.4^{\frac{1}{2}})$$

$$x1\_sij = x1caphsdj + a1\_sij - \sigma AGR2(\{p1\_sij + a1\_sij\} - p1caphsdj),$$

$$i = \text{high speed diesel}, j \in IAGR, (4.14.1.5^{\frac{1}{2}})$$

$$p1caphsdj = \frac{1}{PUR1\_sij + V1CAP\_cj} (PUR1\_sij \times \{p1\_sij + a1\_sij\} + V1CAP\_cj \times \{p1cap\_cj + a1cap\_cj + alprm_j\}),$$

$$i = \text{high speed diesel}, j \in IAGR, (4.14.1.6)$$

$$x1lndfjt_j = x1prmergj - \sigma AGR3(p1lndfjt_j - p1prmergj),$$

$$j \in IAGR, (4.14.1.7)$$

$$x1caphsdj = x1prmergj - \sigma AGR3(p1caphsdj - p1prmergj),$$

$$j \in IAGR, (4.14.1.8)$$

$$x1lab\_rpj = x1prmergj + a1lab\_rpj - \sigma AGR3(p1lab\_rpj - p1prmergj),$$

$$j \in IAGR, (4.14.1.9^{\frac{1}{2}})$$

$$p1prmergj = \frac{1}{\sum_i PUR1\_sij + V1PRM_j} (\sum_i PUR1\_sij \times \{p1\_sij + a1\_sij\} + V1PRM_j \times \{p1prm_j + a1prm_j\}),$$

$$i = \text{fertiliser, high speed diesel}, j \in IAGR, (4.14.1.10^{\frac{1}{2}})$$

The above equations are derived from the series of optimisation problems defined for each level of factor and input aggregation given in Figure 4.14. Hence the derivation procedures resemble that discussed in the above sections. For example the demand for land (x_{1ld_dj}) and fertiliser input (x_{1s_ij}) are derived from the cost minimisation of these inputs subject to a CES function of land-fertiliser composite. σ_{AGR1} to σ_{AGR3} are the elasticities of substitution between land and fertiliser, capital and high speed diesel, and between labour, 'fertiliser-land', and 'capital-diesel', respectively.

The composite demand for land and fertiliser, *i.e.*, $x_{1ldfrtj}$, and the relative prices of these two inputs determines their demands in Equations (4.14.1.1) and (4.14.1.2). The price of land-fertiliser composite input, $p_{1ldfrtj}$, is defined in equation (4.14.1.3). Similarly the price for capital-high-speed-diesel composite ($p_{1caphsdj}$) is determined in equation (4.14.1.6). In equations (4.14.1.7) to (4.14.1.9), the variable $x_{1prmergj}$ represents the composite of all primary factors and the two intermediate inputs. Its price $p_{1prmergj}$ is determined in equation (4.14.1.10).

Electricity and light diesel oil are substitutable in water pumping, therefore, we define 'pumping energy' ($x_{1pumergj}$) as a CES composite of electricity and light diesel oil. Riaz (1984) has estimated own and cross price elasticities of coal, oil, natural gas and electricity for the services, manufacturing and agricultural industries². According to these estimates, electricity's only substitute in the agricultural and services industries is oil. In his study, Riaz has aggregated all petroleum products. In view of the energy consumption pattern in agricultural industries, electricity is most likely to be substituted for light diesel oil which is used for the same operation. The parameter σ_{AGR4j} is elasticity of substitution between electricity and light diesel oil in agricultural industries.

² These price elasticities are used in the study by ENERPLAN discussed in Chapter 3. In that study, Riaz's estimates were modified to meet the two restrictions of symmetry and homogeneity.

$$x1_{sij} = x1_{pumergj} \cdot \sigma_{AGR4j} (\{ p1_{sij} + a1_{sij} \} - p1_{pumergj}),$$

$$i = \text{electricity, light diesel oil, } j \in \text{IAGR, (4.14.1.11)}^{\dagger\dagger}$$

$$p1_{pumergj} = \frac{1}{\sum_i PUR_{sij}} \sum_i (PUR_{sij} \times \{ p1_{sij} + a1_{sij} \}),$$

$$i = \text{electricity, light diesel oil, } j \in \text{IAGR. (4.14.1.12)}$$

The variable $p1_{pumergj}$ represents price for the 'pumping energy' input.

As shown in Figure 4.14, at the top level the Leontief function combines "factor-energy" bundle with "effective non-energy commodities", "pumping energy", and "other costs" inputs. Hence, demands for these composite inputs are in direct proportion to the activity level of the agricultural industries as defined in equation (4.14.1.13) and (4.14.1.14).

$$x1_{prmergj} = atot_j + z_j, \quad j \in \text{IAGR, (4.14.1.13)}$$

$$x1_{pumergj} = atot_j + z_j, \quad j \in \text{IAGR. (4.14.1.14)}$$

Equations that define demand for labour, land and capital ((4.14.1.9), (4.14.1.1) and (4.14.1.4)) for agricultural industries in this sub-section, replace these factor demand equations (4.1 to 4.3) given in Block 4 for these industries. Similarly, equations that define demand for fertiliser (4.14.1.2), electricity and light diesel oil (4.14.1.12), and high speed diesel (4.14.1.5) in this sub-section replace demand equations (5.3) for these intermediate inputs in Block 5 for agricultural industries.

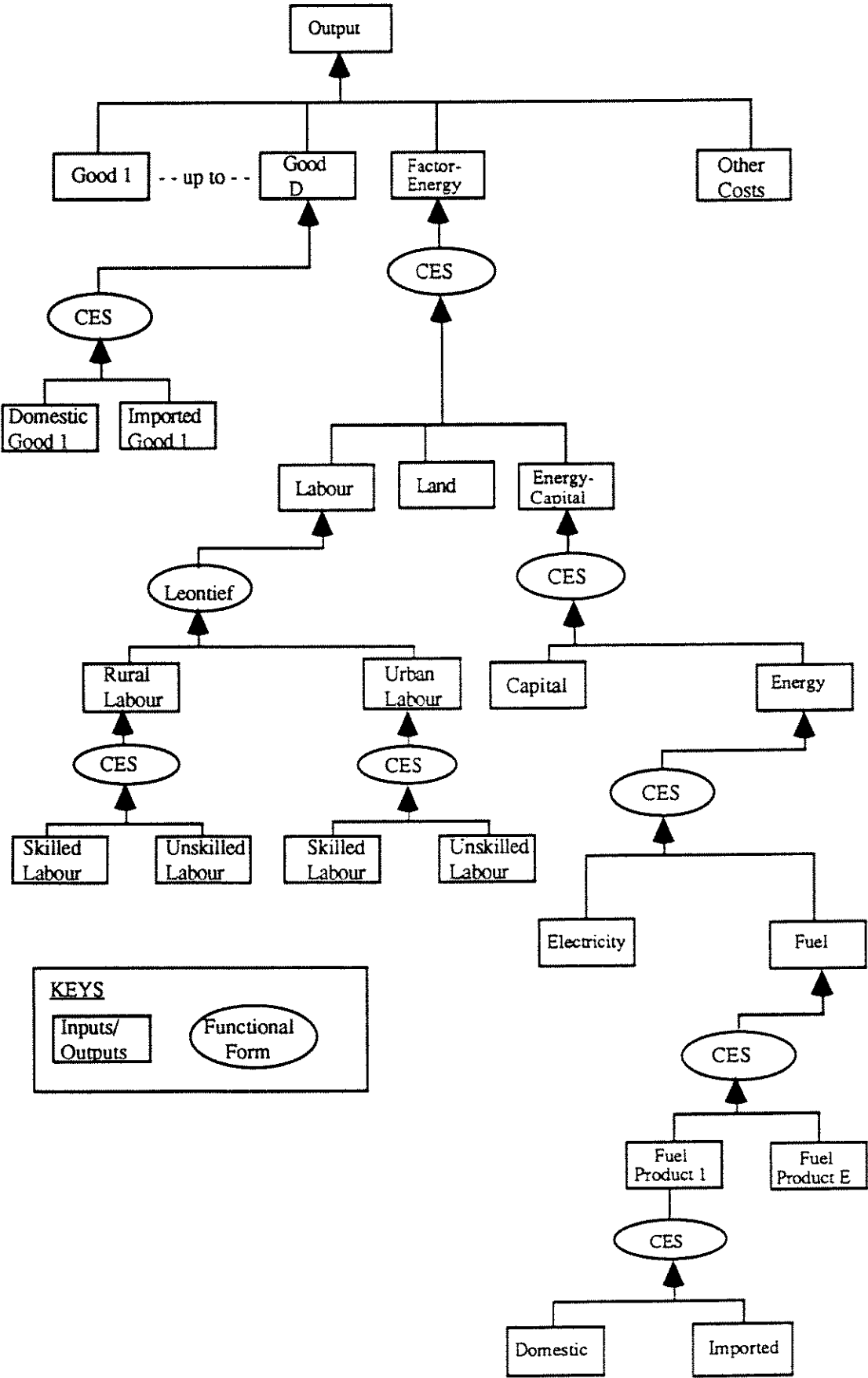
4.14.2 Input Structure for Mining, Manufacturing and Construction Industries

Figure 4.15 shows the assumed input structure for the manufacturing, mining and construction industries. In these industries natural gas, furnace oil and electricity are the major commercial energy sources. According to Riaz's estimates (1984), in the manufacturing industries furnace oil can be substituted only with natural gas. Nevertheless the consumption of energy commodities is specific to the installed capital stock. Hence in the long run, with changes in the capital stock, all energy commodities become substitutes. As shown in Figure 4.15, "fuel" is defined as a CES composite of all energy commodities

(except electricity, which is assumed to be a substitute of "fuel" in a CES production function).

The set of equations discussed in this subsection is based on the nests shown in Figure 4.15. These equations are very similar to that for agricultural industries and represent substitution amongst energy products, and between energy and capital. IIND is a subset of industries and includes the mining, manufacturing and construction industries. The set ERG contains all the names of fuels and electricity while the subset FUL has only fuels names.

Figure 4.15 Input Structure for Manufacturing Mining and Construction



In the following equations the parameters σ_{IIND1} to σ_{IIND3} are elasticities of substitution between fuels, fuel and electricity, and energy and capital respectively for the all industries in set IIND.

$$x1_{sij} = x1_{fulj} + a1_{sij} - \sigma_{IIND1} (\{ p1_{sij} + a1_{sij} \} - p1_{fulj}),$$

$$i \in FUL, j \in IIND, (4.14.2.1\ddagger)$$

$$p1_{fulj} = \frac{1}{\sum_{i \in FUL} PUR1_{Sij}} \left(\sum_{i \in FUL} PUR1_{Sij} \times \{ p1_{sij} + a1_{sij} \} \right),$$

$$j \in IIND, (4.14.2.2)$$

$$x1_{fulj} = x1_{ergj} - \sigma_{IIND2} (p1_{fulj} - p1_{ergj}),$$

$$j \in IIND, (4.14.2.3)$$

$$x1_{sij} = x1_{ergj} + a1_{sij} - \sigma_{IIND2} (\{ p1_{sij} + a1_{sij} \} - p1_{ergj}),$$

$$i = \text{electricity}, j \in IIND, (4.14.2.4\ddagger)$$

$$p1_{ergj} = \frac{1}{\sum_{i \in ERG} PUR1_{Sij}} \left(\sum_{i \in ERG} PUR1_{Sij} \times \{ p1_{sij} + a1_{sij} \} \right),$$

$$j \in IIND, (4.14.2.5)$$

$$x1_{ergj} = x1_{capergj} - \sigma_{IIND3} (p1_{ergj} - p1_{capergj}),$$

$$j \in IIND, (4.14.2.6)$$

$$x1_{cap\_cj} = x1_{capergj} + a1_{cap\_cj} + a1_{prm_j}$$

$$- \sigma_{IIND3} (p1_{cap\_cj} + a1_{cap\_cj} + a1_{prm_j} - p1_{capergj})$$

$$j \in IIND, (4.14.2.7\ddagger)$$

$$p1_{capergj} = \frac{1}{\sum_{i \in ERG} PUR1_{Sij} + V1CAP\_cj} \left(\sum_{i \in ERG} PUR1_{Sij} \times \{ p1_{sij} + a1_{sij} \} \right.$$

$$\left. + V1CAP\_cj \times \{ p1_{cap\_cj} + a1_{cap\_cj} + a1_{prm_j} \} \right),$$

$$j \in IIND. (4.14.2.8)$$

Equations (4.14.2.1) determine the demand for each fuel type while (4.14.2.3) determines the demand for all fuels on aggregate, $x1_{fulj}$. The price of composite of all fuels, $p1_{fulj}$ is determined by equation (4.14.2.2). Similarly, equation (4.14.2.6) determines the composite demand for fuels and

electricity ($x1erg_j$) and its price, $p1erg_j$, is determined in equation (4.14.2.5). In equations (4.14.2.6) and (4.14.2.7), $x1caperg_j$ represents the CES composite of capital and fuel-electricity inputs while this price of this composite input, $p1caperg_j$, is defined in equation (4.14.2.8).

We have assumed that capital is a substitute for "energy", while the "energy-capital" composite is treated as a substitute for labour and land. In all other respects, this input structure resembles that for the agricultural industries. The parameter $\sigma IND4$ is the elasticity of substitution between labour, land and "capital-energy" inputs.

$$x1caperg_j = x1prmerg_j - \sigma IND4 (p1caperg_j - p1prmerg_j), \quad j \in IIND, \quad (4.14.2.9)$$

$$x1lab_{rpj} = x1prmerg_j + a1lab_{rpj} + a1prmj - \sigma IND4 (p1lab_{rpj} + a1lab_{rpj} + a1prmj - p1prmerg_j), \quad j \in IIND, \quad (4.14.2.10\ddagger)$$

$$x1lnd_{dj} = x1prmerg_j + a1lnd_{dj} + a1prmj - \sigma IND4 (p1lnd_{dj} + a1lnd_{dj} + a1prmj - p1prmerg_j), \quad j \in IIND, \quad (4.14.2.11\ddagger)$$

$$p1prmerg_j = \frac{1}{\sum_{i \in ERG} PUR1_{sij} + V1PRM_j} \left(\sum_{i \in ERG} PUR1_{sij} \times \{p1_{sij} + a1_{sij}\} + V1PRRM_j \times \{p1prmj + a1prmj\} \right), \quad j \in IIND. \quad (4.14.2.12)$$

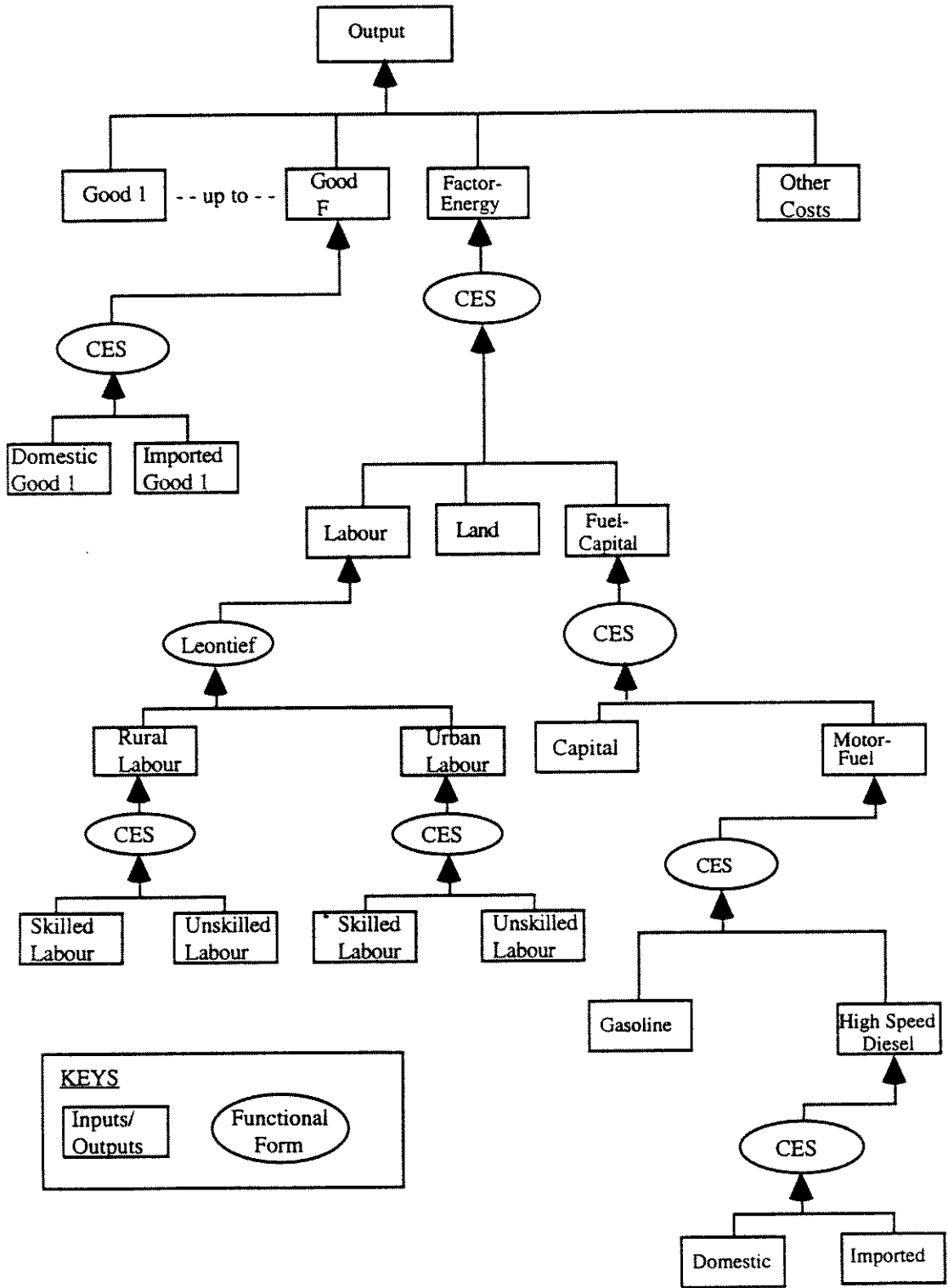
In equations (4.14.2.9) to (4.14.2.11), $x1prmerg_j$, represents a composite of all primary factors and energy products. The price of this composite input, $p1prmerg_j$, is determined in equation (4.14.2.12).

As shown in Figure 4.15, output in industry j is a Leontief composite of non energy goods, "other costs" input, and the "energy-factor" input (see at the top level nest). Consequently the "energy-factor" input demand is in direct proportion to the output or activity level of the industry.

$$x1prmerg_j = atot_j + z_j, \quad j \in IIND. \quad (4.14.2.13)$$

Equations (4.14.2.7), (4.14.2.10) and (4.14.2.11) define demand for capital, labour and land respectively for the industries in the set IIND. These equations replace demand equations (4.1) to (4.3) in Block 4, for capital labour and land for these industries. Equations (4.14.2.1) and (4.14.2.4) replace intermediate input demand equations (5.3) for fuels in Block 5 for the industries in IIND set.

Figure 4.16 Input Structure of the Road Transport Industry



4.14.3 Input Structure for the Road Transport Industry

Figure 4.16 shows the input structure for the road transport industry. Gasoline and high speed diesel are the two major fuels used in road transport. Gasoline is mainly used in taxi-cabs, while all other motor vehicles in public

transport use high speed diesel (Khan, 1984) provides for details of this consumption pattern). Hence the composition of the two fuels is fixed for a given capital stock. As shown in Figure 4.16, at the bottom level, a Leontief production function combines gasoline and high speed diesel to make "motor fuel". The "fuel-capital" is then defined as the CES composite of "motor fuel" and capital stock. The rest of the structure resembles that for the manufacturing industries.

$$x1_{sij} = x1_{fulj} + a1_{sij} - \sigma_{IRDT1}(\{p1_{sij} + a1_{sij}\} - p1_{fulj}),$$

$i = \text{gasoline, high speed diesel, } j \in \text{IRDT, (4.14.3.1}\ddagger)$

$$p1_{fulj} = \frac{1}{\sum_i p_{PUR1_{sij}}} \left(\sum_i p_{PUR1_{sij}} \times p1_{sij} + a1_{sij} \right),$$

$i = \text{gasoline, high speed diesel, } j \in \text{IRDT, (4.14.3.2)}$

$$x1_{fulj} = x1_{capfulj} - \sigma_{IRDT2}(\{p1_{fulj} - p1_{capfulj}\}),$$

$j \in \text{IRDT, (4.14.3.3)}$

$$x1_{cap\_cj} = x1_{capfulj} + a1_{cap\_cj} + a1_{prm_j} - \sigma_{IRDT2}(p1_{cap\_cj} + a1_{cap\_cj} + a1_{prm_j} - p1_{capfulj}),$$

$j \in \text{IRDT, (4.14.3.4}\ddagger)$

$$p1_{capfulj} = \frac{1}{\sum_i p_{PUR1_{sij}} + V1_{CAP\_cj}} \left(\sum_i p_{PUR1_{sij}} \times \{p1_{sij} + a1_{sij}\} + V1_{CAP\_cj} \times \{p1_{cap\_cj} + a1_{cap\_cj} + a1_{prm_j}\} \right),$$

$i = \text{gasoline, high speed diesel, } j \in \text{IRDT, (4.14.3.5)}$

$$x1_{capfulj} = x1_{prmfulj} - \sigma_{IRDT3}(p1_{capfulj} - p1_{prmfulj})$$

$j \in \text{IRDT, (4.14.3.6)}$

$$x1_{lab\_rpj} = x1_{prmfulj} + a1_{lab\_rpj} + a1_{prm_j} - \sigma_{IRDT3}(p1_{lab\_rpj} + a1_{lab\_rpj} + a1_{prm_j} - p1_{prmfulj}),$$

$j \in \text{IRDT, (4.14.3.7}\ddagger)$

$$x1_{lnd\_dj} = x1_{prmfulj} + a1_{lnd\_dj} + a1_{prm_j} - \sigma_{IRDT3}(p1_{lnd\_dj} + a1_{lnd\_dj} + a1_{prm_j} - p1_{prmfulj}),$$

$j \in \text{IRDT, (4.14.3.8}\ddagger)$

$$p1_{prmfulj} = \frac{1}{\sum_i p_{PUR1_{sij}} + V1_{PRRM_j}} \left(\sum_i p_{PUR1_{sij}} \times \{p1_{sij} + a1_{sij}\} + V1_{PRRM_j} \times \{p1_{prm_j} + a1_{prm_j}\} \right),$$

$i = \text{Gasoline, high speed diesel, } j \in \text{IRDT, (4.14.3.9)}$

$$x1_{prmfulj} = atot_j + z_j,$$

$j \in \text{IRDT. (4.14.3.10)}$

In the above equations, the parameters σ_{IRDT1} to σ_{IRDT3} are elasticities of substitution between gasoline and high speed diesel, between motor fuels and capital, and between land, labour and 'capital-fuel' composite inputs. Since these parameters are specific to the road transport industry, we have labelled them with the industry subset. The derivation procedure for these equation is similar to that defined for the nested production function of other industries in the previous sections.

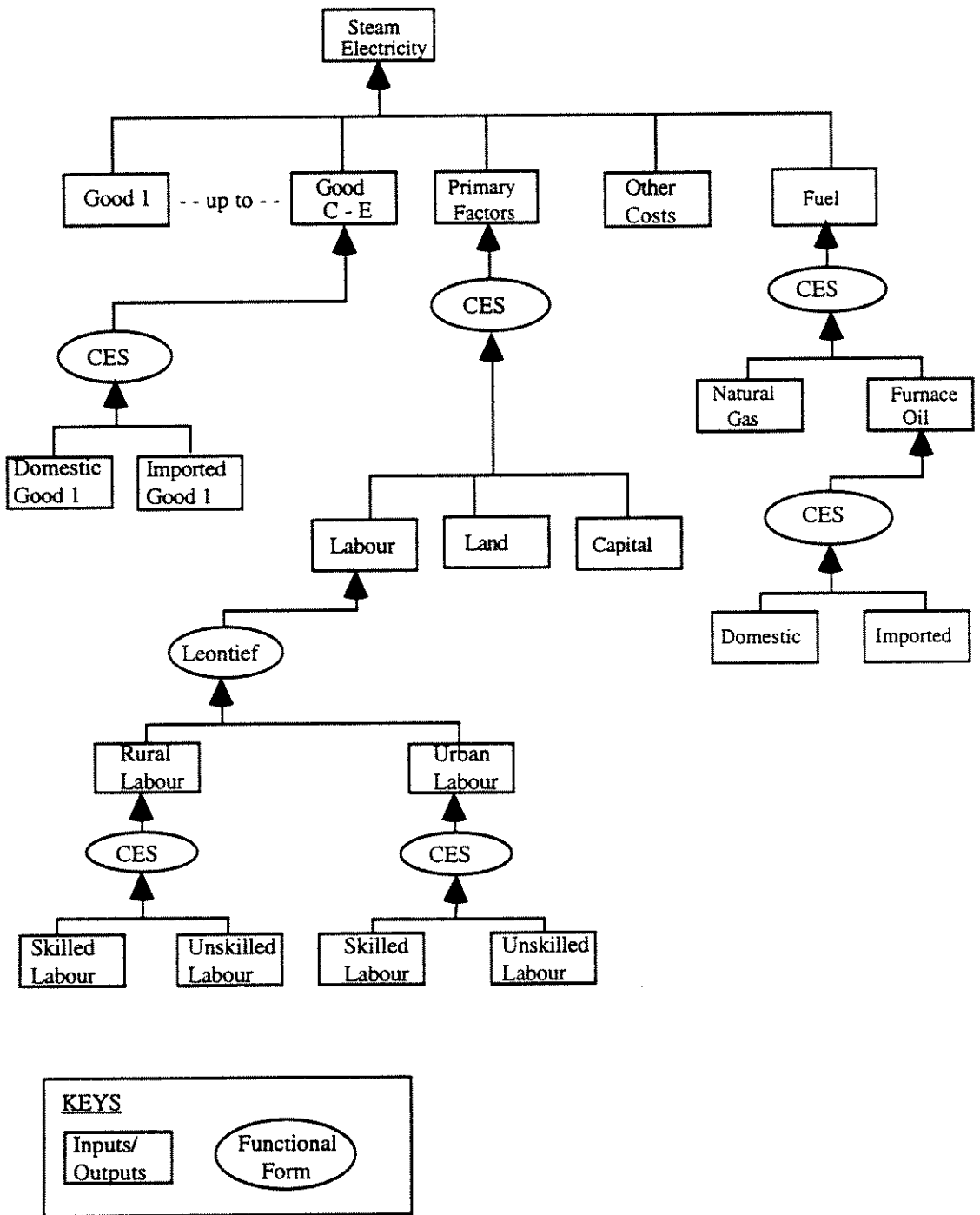
In equations (4.14.3.1) and (4.14.3.3), x_{1fulj} represents the composite demand for the two fuels, *i.e.* gasoline and high speed diesel, while its price (p_{1fulj}) is determined in equation (4.14.3.2). Similarly, $x_{1capfulj}$, represent the composite of capital and the two fuels. The price of this composite input, $p_{1capfulj}$, is defined in equation (4.14.3.5). The CES composite of all primary factors and the two fuels is defined in equation (4.14.3.10) and its price, $p_{1prmfuj}$, is determined in equation (4.14.3.9).

In this sub-section, equations (4.14.3.4), (4.14.3.7) and (4.14.3.8) define demand for capital, labour and land for the road transport industry according to the production structure given in Figure 4.16. These equations replace demand equations of these factors given in equations (4.1) to (4.3) for this industry, in Block 4. Similarly, Equations (4.14.3.1), that define input demand for gasoline and high speed diesel, replace intermediate-input demand equations (5.3) in Block 5 for these fuels for the road transport industry.

4.14.4 Input Structure of the Steam Electricity Industry

In our model there are four electricity industries. This disaggregation is discussed in detail in Section 4.16. In this section we discuss the input structure for the two electricity industries; combined cycle electricity and steam electricity, which have specific patterns of inputs. The input structure of the other two electricity industries resembles that of the default input-structure given in Figure 4.8.

Figure 4.17 Input Structure of the Steam Electricity Industry



Furnace oil and natural gas are the two major fuels in the steam electricity industry. In Pakistan all the steam plants have a dual-firing system. Therefore, the two fuels are substitutes in steam electricity generation. In the steam electricity industry we assume that fuel is a CES composition of natural gas and furnace oil. Figure 4.17 shows this substitution nest and the following

equations define demand equations for the two fuels for the steam electricity industry.

$$x1_{sij} = x1_{fulj} + a1_{sij} - \sigma_{STM}(\{p1_{sij} + a1_{sij}\} - p1_{fulj}),$$

$i = \text{natural Gas, furnace oil, } j \in \text{ISTM, (4.14.4.1)}$

$$p1_{fulj} = \frac{1}{\sum_i PUR1_{sij}} \left(\sum_i PUR1_{sij} \times \{p1_{sij} + a1_{sij}\} \right),$$

$i = \text{natural gas, furnace oil, } j \in \text{ISTM, (4.14.4.2)}$

$$x1_{fulj} = atot_j + z_j, \quad j \in \text{ISTM. (4.14.4.3)}$$

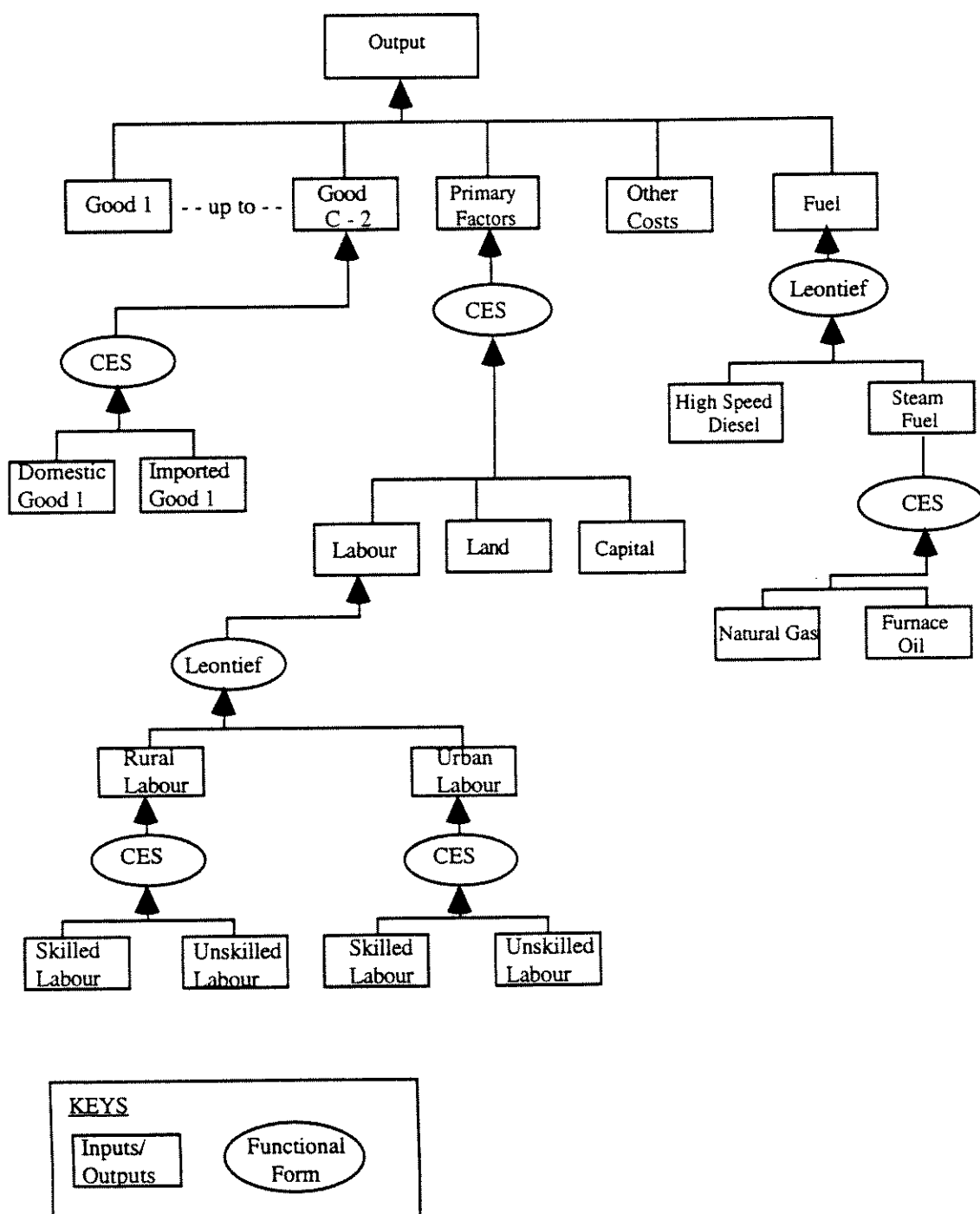
The parameter σ_{STM} is the elasticity of substitution between natural gas and furnace oil in steam electricity generation. The other input demand equations are defined in Section 4.13 along with all the equations for other industries. In these new equations, $x1_{fulj}$, represent CES composite of the two fuels and $p1_{fulj}$ represent its price.

In this sub-section, equations (4.1.4.4.1) define input demand for natural gas and furnace oil for the steam electricity industry. These equations replace the demand equation for intermediate-input (5.3) for these two fuels, in Block 5, for the steam electricity industry.

4.14.5 Input Structure for the Combined Cycle Electricity Industry

Figure 4.18 shows the pattern of energy substitutions for the combined cycle electricity industry. In this industry, natural gas and high speed diesel are the major fuels. A combined cycle plant consists of two steam plants and one gas turbine plant. Since steam plants can be operated on furnace oil and natural gas, we assume that "steam fuel" is a CES composite of natural gas and furnace oil. At the top level, a Leontief production function aggregates "steam fuel" with high speed diesel. The latter is used by the gas turbine plant.

Figure 4.18 Input Structure of Combined Cycle Electricity Industry



The fuel demand equations for the combined cycle electricity industry are defined below. The parameter σ_{ICCY} is the elasticity of substitution between natural gas and furnace oil for the combined cycle electricity industry. Fuel demand is an input to the Leontief production function defined in the top level nest of Figure 4.18. Therefore, the demand for fuel ($x_{1stmfulj}$)

is in direct proportion to electricity production in the industry. The price of this composite input is represented by $p1stmful_j$, which is defined in equation (4.14.4.2). At the second-level of the fuel-substitution nest, fuel input is a Leontief composite of steam fuel and high speed diesel. Therefore, demands for these two inputs are in direct proportion to the output level.

$$x1_{sij} = x1stmful_j + a1_{sij} - \sigma ICCY(\{ p1_{sij} + a1_{sij} \} - p1stmful_j) ,$$

$$i = \text{natural gas, furnace oil, } j \in ICCY, \text{ (4.14.4.1\ddagger)}$$

$$p1stmful_j = \frac{1}{\sum_i PUR1_{sij}} \left(\sum_i PUR1_{sij} \times \{ p1_{sij} + a1_{sij} \} \right),$$

$$i = \text{natural gas, furnace Oil, } j \in ICCY, \text{ (4.14.4.2)}$$

$$x1stmful_j = atot_j + z_j , \qquad j \in ICCY, \text{ (4.14.4.3)}$$

$$x1_{sij} = atot_j + z_j , \qquad i = \text{high speed diesel, } j \in ICCY. \text{ (4.14.4.4)}$$

Equations (4.14.4.1), which determine input demand for natural gas and furnace oil, replace equations (5.3) in Block 5 for these inputs for the combined cycle industry.

4.15 Output Structure of Industries

As discussed, GE-PAK allows multiple output industries. In this study we have three categories of industries. Figure 4.19 gives a schematic representation of the three categories.

Figure 4.19 Three Categories of Industries with respect to Output Structure

Industries	Single Output	Multiple Output
Single Industries	All industries other than oil & gas, refinery and electricity industries.	oil & gas industry refinery industry.
Multiple Industries	electricity industries.	

In the first category every industry produces a single commodity which is not produced by any other industry. For example, "large-farm wheat" commodity is produced by only the "large-farm wheat" industry. All industries, other than the oil & gas, refinery and electricity industries, belong to the first category.

For all these industries the Leontief composite of multiple inputs determines the output level of the commodity produced by the industry.

The oil & gas and refinery industries belong to the second category in which each industry produces more than one commodity but no other industry produces these commodities. For example as shown in Figure 4.20, the oil & gas industry produces two commodities which are not produced by any other industry. The refinery industry produces six types of petroleum products as shown in Figure 4.21. The CET specification in the refinery industry allows us to choose the degree of substitution in the output of these products. We can assume a Leontief aggregation of these petroleum products by setting the CET value to zero.

The four electricity industries belong to the third category of industries, in which each industry produces a single commodity but that commodity is the output of more than one industry. Hence, electricity is produced by more than one industry. To aggregate electricity production we assume that there is an electricity utility which aggregates electricity produced by the four industries to meet electricity demand. We refer to the aggregation of electricity produced by four industries as the supply structure of electricity, which is discussed in detail in Section 4.16.

Figure 4.20 Production Structure of the Oil & Gas Industry

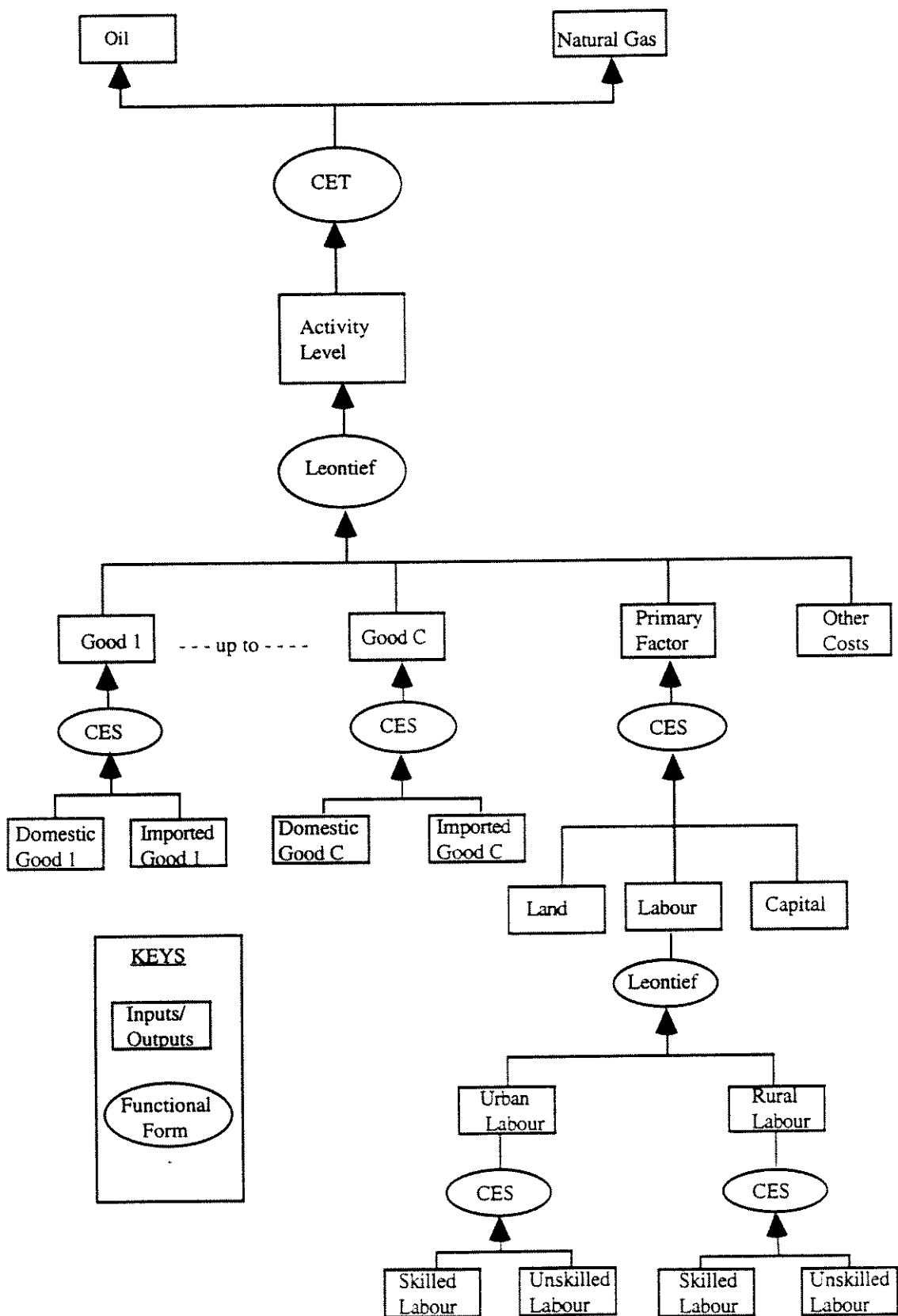
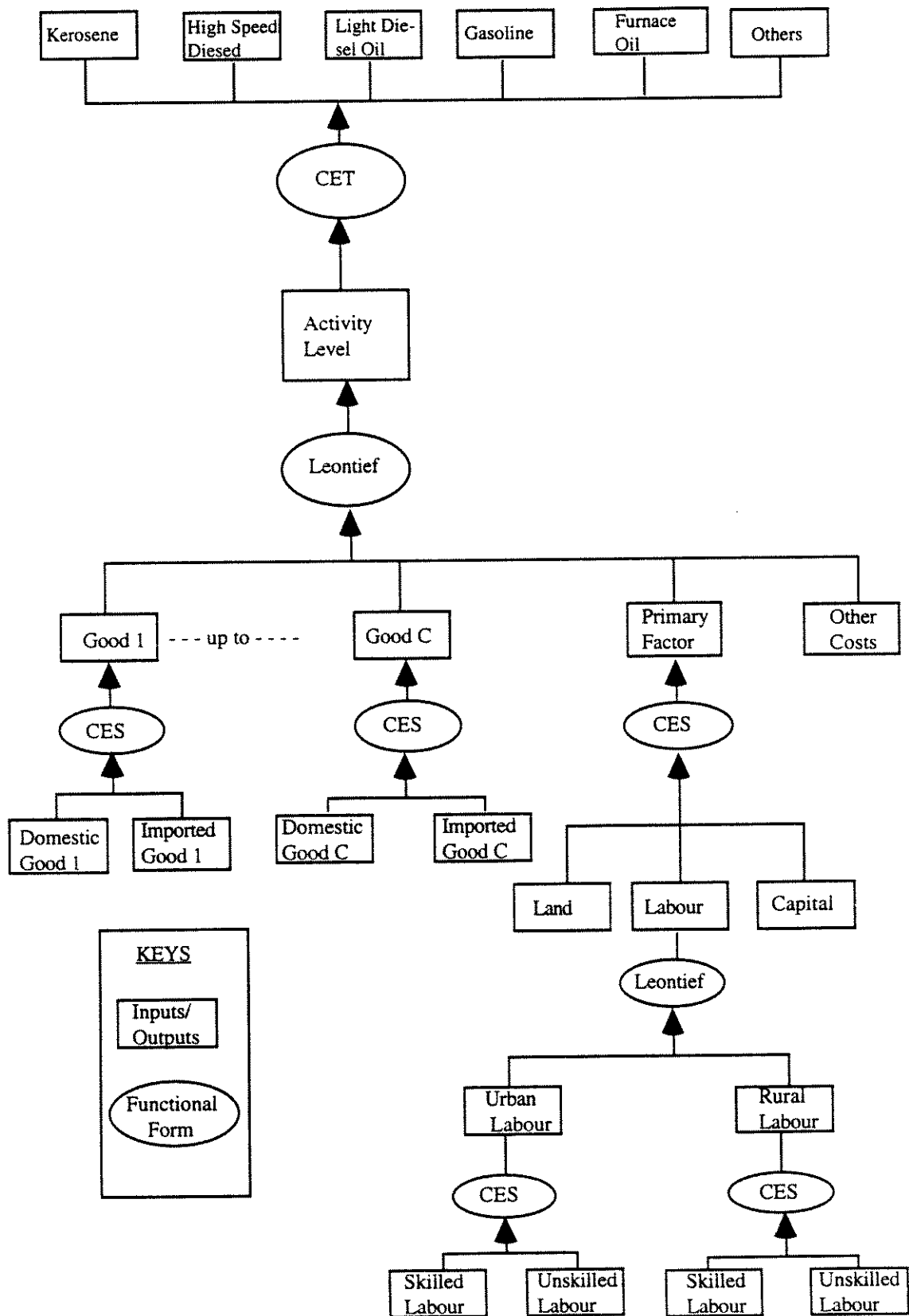


Figure 4.21 Production Structure of the Refinery Industry



In this section we discuss a set of equations that determines output levels in multiple-output-single industries. These equations correspond to the top level nest given in Figure 4.20 and Figure 4.21.

Block 6 Equations for output-mixes in industries.

$$x_{0ij} = z_j + \sigma_{OUTj} (p_{0domi} - p_{0indj}), \quad i \in COM, j \in IND, \quad (6.1)$$

$$p_{0indj} = \frac{1}{\sum_{i \in COM} MAKE_{ij}} \sum_{i \in COM} MAKE_{ij} \times p_{0domi}, \quad j \in NONIELE, \quad (6.2)$$

$$x_{0domi} = \frac{1}{\sum_{j \in NONIELE} MAKE_{ij}} \sum_{j \in NONIELE} MAKE_{ij} \times x_{0ij}, \quad i \in NONCELE, \quad (6.3)$$

The above equations are derived from the following optimisation problem (see Appendix A for the derivation).

The total revenue from all outputs in industry j is maximised subject to the transformation frontier:

$$Z_j = CET(X_{0ij}), \quad i \in COM, j \in IND. \quad (4.15.1)$$

The solution to this problem is given in equation (6.1). The CET aggregation function is identical to CES, except that the transformation parameter in the CET function has the opposite sign to the substitution parameter in the CES function. Here, an increase in the price of a commodity, relative to the average price, induces transformation in favour of that output. The average price in equation (6.1), p_{0indj} is the average unit-revenue of industry j . It is defined by equation (6.2) as the weighted-average of prices of commodities produced by industry j . $MAKE_{ij}$ elements give the output values of commodities produced by industry j . Equations (6.1) state that commodity i in industry j is produced in proportion to the activity level, Z_j , and to a price term. The price term consists of an elasticity of transformation, σ_{OUTj} , multiplied by the price of commodity i relative to the average price received by the industry. The symbol for the average unit-revenue, p_{0indj} , is the same as that used in the equations set covered in Block 4 to refer to the effective price of a unit of activity. This confirms our interpretation of equation (5.4) as a zero pure-profit condition.

Although only two industries have multiple outputs, we have defined these equations for all industries for the sake of uniformity and algebraic convenience. For single-output industries, $p0_{dom_i}$ is equal to the corresponding $p0_{ind_j}$. Hence, the output of commodity i is produced in direct proportion to the activity level z_j .

Equation (6.3) defines the total supply of domestically produced commodities as the weighted-sum of commodity supplies from all industries. The shares are computed using the MAKE matrix, which contains the supply of commodity i by industries.

Equations (6.1) to (6.3) are active for all industries other than the four electricity industries because the productions in those four industries are determined according to a supply structure. NONIELE is the subset of industries that contains all non-electricity industries and NONCELE is the subset of commodities excluding electricity. In equation (6.1) we set the value of σ_{OUT} to zero to map output level in each industry determined in the electricity module to the activity variable of each electricity industry.

In the model there are four electricity industries. The composition of electricity supplied by these industries is defined in a separate electricity module discussed in the next section.

4.16 Electricity Supply Structure

In this section we present the module that determines the composition of electricity supplies from four electricity industries. Block 7 contains the equations determining electricity supply from the four industries, according to the supply structure given in Figure 4.23. After reviewing electricity industries in Pakistan, we discuss the assumed supply structure of electricity in the model.

In Pakistan there are two major sources of electricity generation, hydro and thermal. Thermal electricity is generated by three types of plant:

- combined cycle;

- steam generator; and
- gas turbine.

Each type of electricity plant has a different composition of capital costs, fuel costs, and types of fuel consumed. The four types of plant also differ in engineering characteristics, as follows.

- Capacity factor—this indicates the generating mode for which a plant is designed, *i.e.*, base load, intermediate load, or peak load.
- Starting time; time required to start generation from a plant.
- Fast-spinning-surge capability, which refers to the time required to increase generation in the event of a sudden increase in electricity demand or failure of another plant.
- Percent of the plant capacity that can be used for fast-spinning reserve.
- Time required to generate at the full capacity after a cold start up.
- Instant on-off capability.

GE-PAK distinguishes between the four types of electricity plant by identifying four industries which are operated by an electricity utility. The utility combines output from these four industries to meet the electricity demand. The contribution of each industry in total electricity supply is determined by its economic cost of production, and by operational constraints in electricity generation. Thus the model makes two assumptions:

- each electricity industry minimises the cost of producing a given level of output which it supplies to the electricity utility; and
- the job of the electricity utility is to supply electricity to all consumers. As consumers have a certain pattern of electricity demand, the utility aggregates electricity generated by the four industries according to the demand pattern.

The objective of this section is to discuss a two-level electricity supply function for the utility that aggregates electricity generated by the four industries. We discuss:

- first, the nature and pattern of electricity demand in general;
- second, the operational characteristics of four types of electricity plant and the constraints in combining electricity generated by these plants; and
- third, a two-level electricity supply function that allows substitution between electricity generated by the four types of plants under their operational constraints.

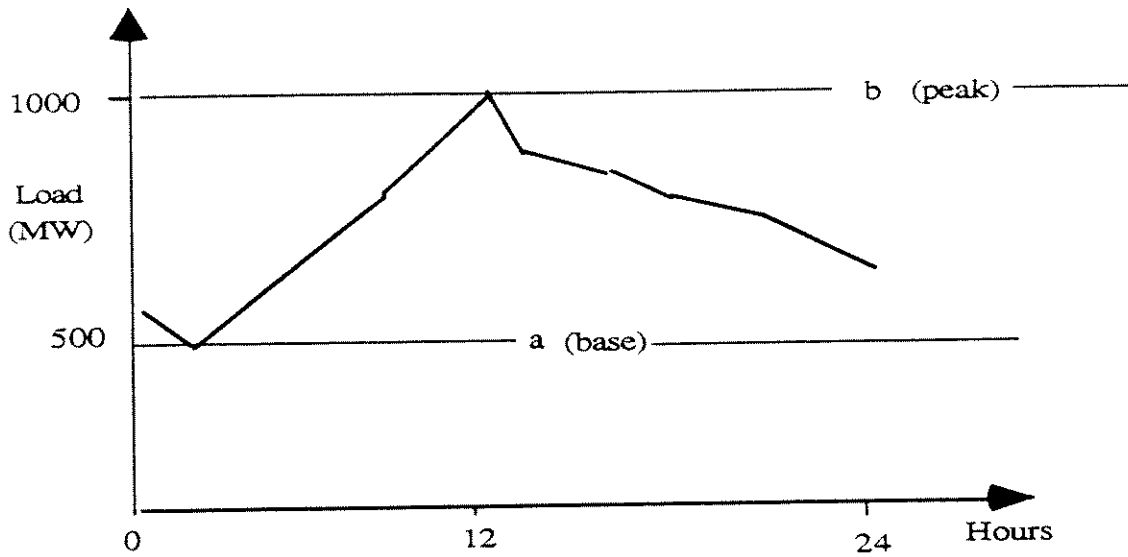
4.16.1 Nature and Pattern of Electricity Demand

At a point in time, electricity demand is for electricity power measured in units of Megawatt (MW), and is called "Load" demand. As the consumer demand for power (MW) varies with time say—from one hour to another—the total electricity demand in a day (24 hours) is defined as:

$$ELEC = \int_0^{24} LOAD(t) dt \quad (4.16.1)$$

where ELEC is Megawatt-hours (MWH) of electricity demand, and LOAD is defined in megawatt (MW) units which vary in the range of 'a' (the base load level) to 'b' the peak load level. A hypothetical daily load curve with a sharp afternoon peak load is shown in Figure 4.22. The area under the curve is the total electricity requirement, in units of megawatt-hours. The shape of the curve shows the pattern of power demand.

Figure 4.22. Hypothetical Daily Load Curve



4.16.2 Operational Constraints in Electricity Generation and Operational Characteristics of Electricity Plants

To meet both daily and seasonal variations in load demand, electricity is supplied by combining output from different types of plant. The electricity plants are brought into production in a certain order, referred to as the 'loading order'. This ranks available electricity plants according to cost per MWH (least cost plants are placed first), and the 'operational constraints' of the electricity system which requires smooth supply of electricity at least cost.

Two of the operational constraints on the electricity supply are as follows.

- (1) As the demand for load varies, the electricity system should be able to adjust production without any losses.
- (2) If there is a sudden increase in the load demand or failure in a plant there should be some units that have the capability to start production in a short time.

Table 4.4 Typical Characteristics of Electricity Plants

Types of Plant	Fast Spinning Reserve Capability		Maximum Rate of Sustained Load Change†	Startup Time
	1	2		
	Available % of Rating	Time Required (second)		
Steam (gas or oil)	30	30	2-5% per minute	Hours
Coal	15-20	10-30	2-5% per minute	Hours
Nuclear	8-20	10-30	1.5-3% per minute	Hours
Gas turbine	100	5	20% per second	1-10 minute†
Hydro	0-100†	10	1%-10% per second	1-5 minute†

Source: International Atomic Energy Agency, Vienna, (1984), Table 7.IV.

† for various types of plants within the category

Table 4.4 shows the operational characteristics of 5 types of electricity plant. The fast spinning reserve capability of an electricity plant refers to the time required to increase electricity generation from the plant if there is a sudden increase in electricity demand, or the failure of another unit. Column 2 shows the fast spinning reserve capability of various types of plants, while column 1 shows the percentage of their capacity that has this fast spinning capability. It appears that hydro plants and gas turbines have about the same level of fast spinning reserve capability and about the same percentage of capacity available to utilise it. Fossil steam and nuclear plants are comparable in their fast spinning reserve capability. Turning to start up time, the gas turbine and hydro plants are fast while the other two types of plant are slow.

Column 3 of Table 4.4 shows that for sustained load changes, the response of the hydro and gas turbine plants are similar, and are much faster than the other plants.

The combined cycle plants consist of steam plants and gas turbines. Hence their operational characteristics are overlapping. These plants can be grouped with gas turbine plants or steam plants depending on their cost of production and the duties assigned to them in the generation system.

4.16.3 Two-level Nested Electricity Supply Structure

On the demand side, the model computes the percentage change in total electricity demand (MWH). We assume that the pattern of electricity use does not change with total electricity demand. However, we need to allow substitution between electricity generated by the four types of plants for two reasons:

- changes in the distribution of electricity supply by a type of plant, required to meet the change in total electricity demand; and
- changes in the relative production costs of the four types of plants.

GE-PAK incorporates the following four electricity industries, each representing a plant type.

- (1) Hydro electricity industry.
- (2) Gas turbine electricity industry.
- (3) Steam electricity industry.
- (4) Combined cycle electricity industry.

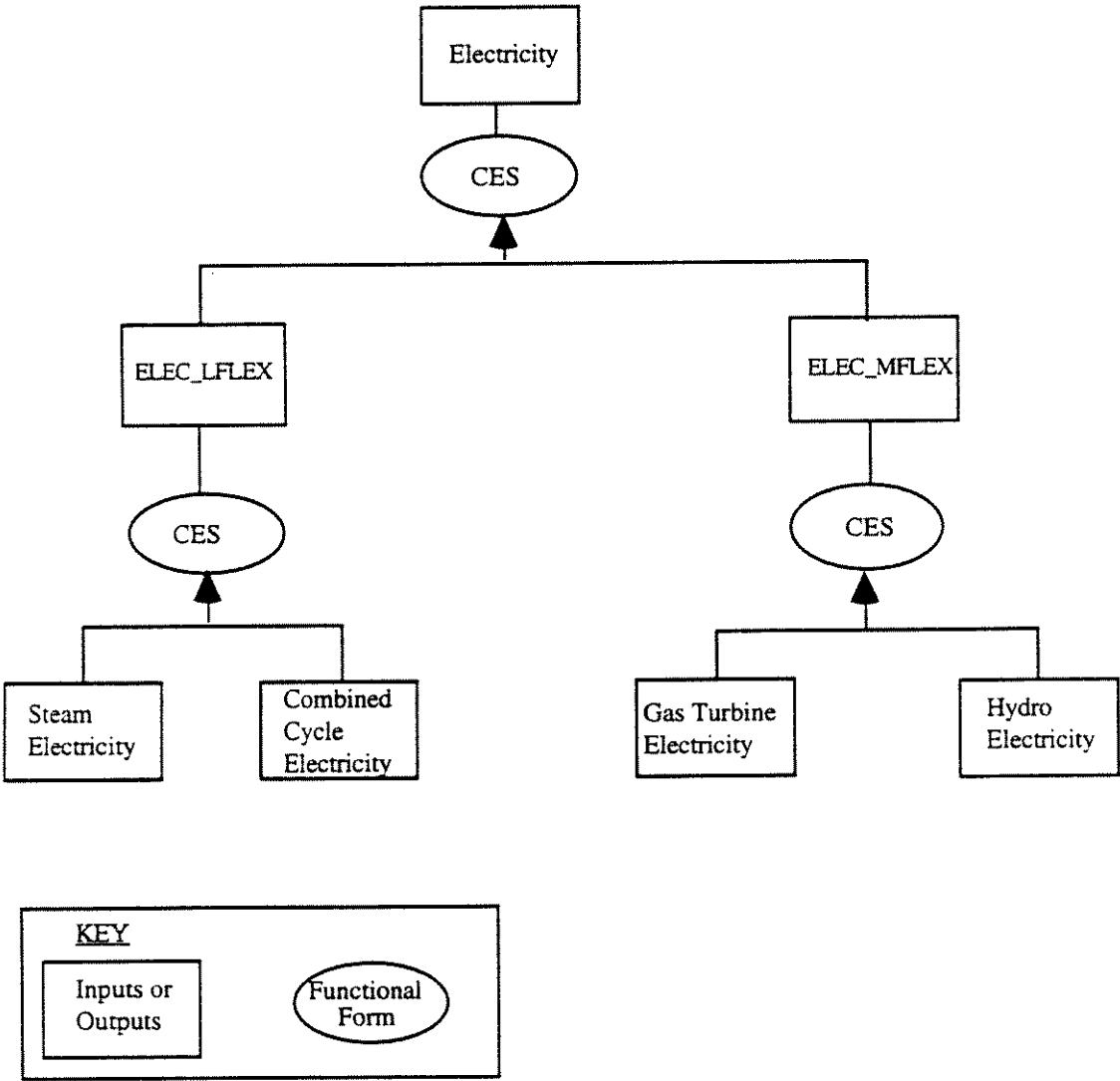
On the basis of their operational characteristics, these industries have been grouped into two categories.

- (i) ELEC_MFLEX; more flexible technology group which consists of the hydro and gas turbine electricity industries; and
- (ii) ELEC_LFLEX; less-flexible technology group which consists of steam and combined cycle electricity. We have included combined cycle

plants in this category, because in Pakistan the production cost of electricity by these plants is closer to that of steam plants, and the two types of plants are assigned similar duties.

We have defined a two-level nested function that aggregates electricity supplies from the four industries, categorised by two types of technology. Figure 4.23 shows the structure of this function.

Figure 4.23 Electricity Supply Structure



In Figure 4.23, the top level nest shows that total electricity demand is a CES composite of elec_mflex (electricity generated by the more flexible technology) and elec_lflex (electricity generated by the less flexible technology). The top level nest represents substitution possibilities in electricity generation by industries with low and high flexibility. The bottom

level nest shows the substitution possibilities in electricity generation by industries with same type of technology. Electricity generated by the more flexible technology (elec_mflex) is a CES composite of generation from the gas turbine and hydro industries. Electricity generated by the less flexible technology (elec_lflex) is a CES composite of generation from the steam and combined cycle industries.

Block 7 Equations of electricity supply structure

$$x0_{ij} = x0_{elec\_lflex} - \sigma_{IELEL} (p0_{indj} - p0_{elec\_lflex}), \quad i = \text{electricity}, j \in ILFLX, \quad (7.1)$$

$$p0_{elec\_lflex} = \frac{1}{\sum_{j \in ILFLX} MAKE_{ij}} \left(\sum_{j \in ILFLX} MAKE_{ij} \times p0_{indj} \right), \quad i = \text{electricity}, \quad (7.2)$$

$$x0_{ij} = x0_{elec\_hflex} - \sigma_{IELEM} (p0_{indj} - p0_{elec\_hflex}), \quad i = \text{electricity}, j = IMFLX, \quad (7.3)$$

$$p0_{elec\_hflex} = \frac{1}{\sum_{j \in IHFLX} MAKE_{ij}} \left(\sum_{j \in IHFLX} MAKE_{ij} \times p0_{indj} \right), \quad i = \text{electricity}, \quad (7.4)$$

$$x0_{elec\_lfflex} = x0_{domi} - \sigma_{IELE} (p0_{elec\_lflex} - p0_{domi}), \quad i = \text{electricity}, \quad (7.5)$$

$$x0_{elec\_hflex} = x0_{domi} - \sigma_{IELE} (p0_{elec\_hflex} - p0_{domi}), \quad i = \text{electricity}, \quad (7.6)$$

$$p0_{domi} = \frac{1}{\sum_{j \in IELE} MAKE_{ij}} \left(\sum_{j \in IELE} MAKE_{ij} \times p0_{indj} \right), \quad i = \text{electricity}. \quad (7.7)$$

ILFLX is a set of low flexible electricity industries and IMFLX is a set of more flexible industries.

The supply equations in Block 7 are derived from the solution to the two-part cost-minimisation problem of the electricity utility. At the bottom level the total cost of supply from less-flexible technologies is minimised subject to the following CES supply function:

$$X0_{ELEC\_LFLEX} = CES(X0_j), \quad j \in ILFLX. \quad (4.16.2)$$

The total cost of supply from high-flexible technologies is minimised subject to the CES supply function

$$X0ELEC\_HFLEX = CES(X0_j), \quad j \in IHFLX. \quad (4.16.3)$$

The solutions to the two optimisation problems in percentage-change form are given in the equations covered in Block 7 (see Appendix A for the derivation). Equations (7.1) state that the generation of electricity in the steam and combined cycle electricity industries are in proportion to the total electricity supply from the less-flexible electricity industries ($x0elec\_lflex$), and a price term. In all the equations, variables beginning with "p0" are the basic prices of electricity production and, hence, represent the production costs. The price terms in equation (7.1) consist of a substitution elasticity, $\sigma IELEL$, multiplied by the price ratio representing the price of electricity from industry j relative to the average price ($poelec\_lflex$); which is weighted-average price of electricity from less flexible technologies. Equation (7.2) defines this cost-weighted average price of electricity from industries with less flexible technology. Change in the relative production costs of the two electricity industries induces substitution in favour of the industry with reduced production cost. The elasticity parameter, $\sigma IELEL$, represents substitution possibilities in electricity generation by different electricity industries with low flexible technology.

Equations (7.3) to (7.4) determine electricity generation in the industries with more flexible technology, *i.e.*, the hydro and gas turbine industries. These equations resemble those for low-flexible electricity industries and have similar interpretations while $\sigma IELEL$ represents the substitution possibilities in electricity generation by different electricity industries with high flexible technology.

The total cost of electricity supply from the two types of technology is minimised subject to a production function

$$X0ELEC = CES (X0ELEC\_LFLEX, X0ELEC\_HFLEX), \quad (4.16.3)$$

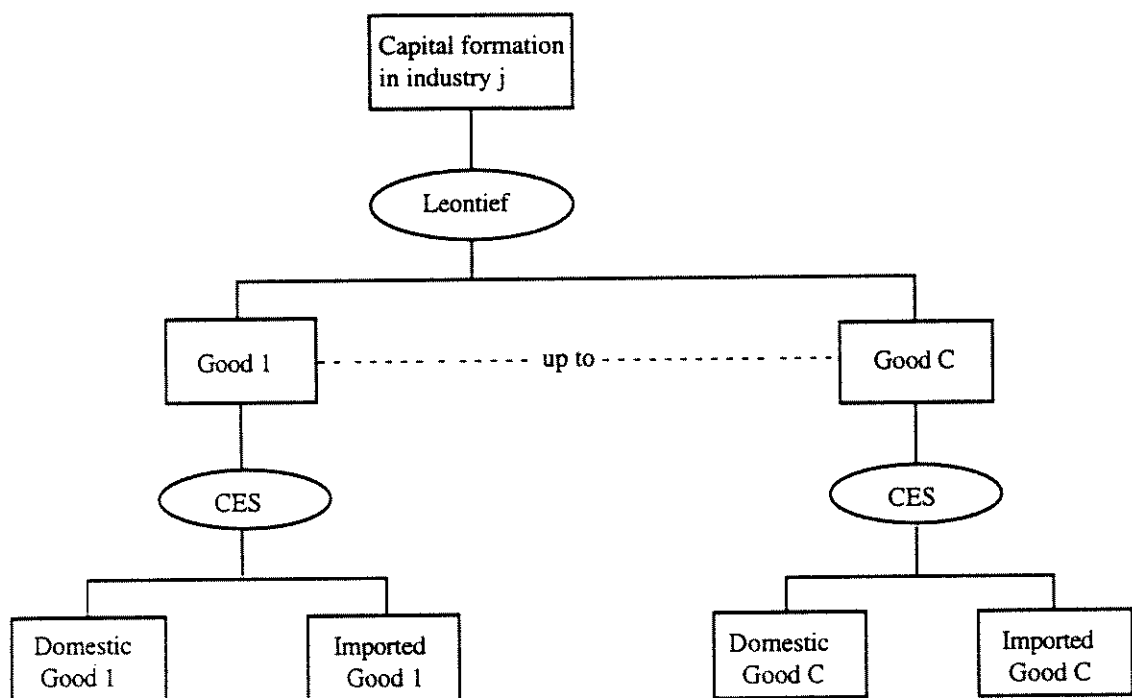
as shown in the top level nest of Figure 4.23. The solution to this problem in percentage-change form is given in Block 7. In equations (7.5) and (7.6) electricity generation by two types of technology is determined in proportion to the total supply of electricity and a price term. The price term consists of the weighted average price of electricity generation from a technology and the overall price of electricity. The latter is, again, a cost-weighted average of the generation cost from the two types of technology.

The elasticity parameter σ_{IELE} represents substitution possibility in electricity generation from two types of technology. However, σ_{IELE} is governed by the consumers' ability to change the demand pattern for electricity. A high value of σ_{IELE} represents flexibility in the pattern of electricity demand while a low value shows the rigidity in this pattern.

4.17 Demands for Commodities for Capital Formation

Figure 4.24 shows the nesting structure for the production of new units of fixed capital. Capital is assumed to be produced with inputs of domestically produced and imported commodities. No primary factors are used directly as inputs to capital formation. This structure resembles the production structure which governs intermediate inputs to current production.

Figure 4.24 Formation Structures of Capital Goods



The demand equations for commodities in Block 8 are derived from the solutions to the investors' two-part cost minimisation problem. At the bottom level, the total cost of good i , from the two sources, is minimised subject to the CES production function

$$X2_{sij} = \text{CES}_{s \in \text{SRC}} \left(\frac{X2_{isj}}{A2_{isj}} \right), \quad i \in \text{COM}, j \in \text{IND}. \quad (4.17.1)$$

While at the top level, total cost of inputs (all composite commodities) is minimised subject to the Leontief production function:

$$Y_j = \text{MIN}_{i \in \text{COM}} \frac{1}{A2_{isj}} \left(\frac{X2_{sij}}{A2_{sij}} \right), \quad j \in \text{IND}. \quad (4.17.2)$$

Total value of investment in each industry, Y_j , is exogenous to the cost-minimisation problem and is determined by other equations, given in Block 21.

Equations (8.1) to (8.3) determine the demands for source-specific inputs and for composite inputs for capital formation. The source-specific demand equation (8.1) for commodities requires an elasticity of substitution parameter, $\sigma_{\text{COM}2i}$, that gives substitution possibility between domestic and

imported intermediate input i . Equation (8.4) determines the price of a new unit of capital as the average cost of producing it—a zero pure-profit condition.

Block 8 Equations of demand for commodities for capital formation

$$x_{2isj} = x_{2sij} + a_{2isj} - \sigma_{COM2i} [(p_{2isj} + a_{2isj}) - p_{2sij}],$$

$i \in COM, s \in SRC, j \in IND, (8.1)$

$$p_{2sij} = \frac{1}{PUR_{2sij}} \left(\sum_{s \in SRC} PUR_{2isj} (p_{2isj} + a_{2isj}) \right),$$

$i \in COM, j \in IND, (8.2)$

$$x_{2sij} = y_j + a_{2isj} + a_{2sij},$$

$i \in COM, j \in IND, (8.3)$

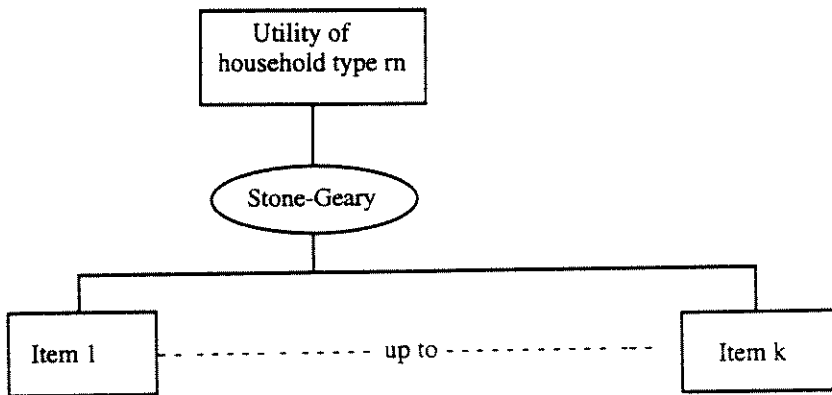
$$p_{2isj} = a_{2isj} + \frac{1}{PUR_{2isj}} \left(\sum_{i \in COM} PUR_{2sij} (p_{2sij} + a_{2sij}) \right),$$

$j \in IND. (8.4)$

4.18 Households' Demands for Items

Horridge *et al.*, (1993) have given a very simple and systematic procedure to derive demand equations (in percentage-change form) for household with LES demand system. We have adopted that procedure to derive equations of households' demand for consumption items. As shown in Figure 4.25, it is assumed that the households derive utility from the consumption of items, which are aggregated by a Stone-Geary function leading to LES demand functions.

Figure 4.25 Structure of Household Demand



In the model there are 7 types of household in each region (see Subsection 4.4.6 for categories of households). Block 10 shows the equations

determining demand for items for each household category while Block 9 covers formulas to compute parameters of the equations.

To analyse the Stone-Geary utility function, it is helpful to divide consumption of each item (XITEM) by household type m into two components: a luxury (or supernumerary) part, XITEMLUX; and a subsistence (or minimum) part, XITEMSUB. By definition then,

$$XITEM_{km} = XITEMSUB_{km} + XITEMLUX_{km},$$

$$k \in ITM, r \in REG, n \in INC. (4.18.1)$$

In percentage-change form, equation (4.18.1) is defined as

$$xitem_{km} = (1 - ALPHA\_I_{km}) \times xitemsub_{km} + ALPHA\_I_{km} \times xitemlux_{km},$$

$$k \in ITM, r \in REG, n \in INC, (4.18.2)$$

where, $ALPHA\_I_{km}$, is the share of supernumerary expenditure on item k in the total expenditure on k , by household type m (Appendix B shows the formulas used to arrive at percentage-change forms). As shown in Block 9, $ALPHA\_I_{km}$, are computed by using econometric estimates of the Frisch parameter ($FRISCH_m$) and expenditure elasticities of consumption items (EPS_{km}) for household type n in region r . $FRISCH_m$ represent the reciprocal of share of luxury expenditure in total expenditure of household type m .

Block 9 Coefficients in household demand equations

$$ALPHA\_I_{km} = ALPHA_m \times EPS_{km}, \quad k \in ITM, r \in REG, n \in INC, (9.1)$$

$$ALPHA_m = (-1/FRISCH_m), \quad r \in REG, n \in INC, (9.2)$$

$$DELTA_{km} = EPS_{km} \times \frac{VITEM_{km}}{VITEM\_k_m}, \quad k \in ITM, r \in REG, n \in INC. (9.3)$$

The consumption demand by household type n , has a subsistence component proportional to the number of households (Q_p_m) in category n and region r , and to a taste-change variable, AITEMSUB $_{km}$. Hence in the percentage-form $xitemsub_{km}$ can be defined as:

$$xitemsub_{km} = q\_p_m + aitemsub_{km}, \quad k \in ITM, r \in REG, n \in INC. (4.18.3)$$

Only the luxury components enter into a household utility function which is assumed to be maximised by the households. The utility function has the well-known Cobb-douglas form,

$$UTILITY_m = \frac{1}{Q_{-Pm}} \prod_k XITEMLUX_{kr}^{DELTA_{km}} \quad r \in REG, n \in INC, (4.18.4)$$

where $\sum_k DELTA_{km} = 1$. The demand equations derived from the solution to this problem in percentage-change form are given in the equations given below.

$$xitemlux_{km} = luxexp_m + aitemlux_{km} - pitem_k, \quad k \in ITM, r \in REG, n \in INC, (4.18.5)$$

$$utility'_m + q_{-p_m} = \sum_k (DELTA_{km} \times xitemlux_{km}), \quad r \in REG, n \in INC. (4.18.6)$$

The coefficients, $DELTA_{km}$, in equation (4.18.6) are marginal household budget shares of item k in the budget of household type m (see formula in equation (9.3) in Block 9). Note that the Cobb-Douglas form gives rise to exogenous budget shares for spending on luxuries,

$$XITEMLUX_{km} \times PITEM_k = DELTA_{km} \times LUXEXP_m, \quad k \in ITM, r \in REG, n \in INC, (4.18.7)$$

where, $LUXEXP_m$, is the household's total expenditure on luxuries. The coefficient $DELTA_{km}$, therefore, may be interpreted as the marginal budget share of item k in the total spending on luxuries.

We arrived at equations (10.1) in Block 10 by replacing $xitemsub_{km}$ and $xitemlux_{km}$ in equation (4.18.2) with those in equation (4.18.3) and (4.18.5). Similarly, we replace $xitemlux_{km}$ in equation (4.18.6) to arrive at equation (10.4) in Block 10.

Equation (10.1) states that the demand for a consumption item for household type m is determined by the number of households in that category, the shift in taste for subsistence and luxury consumption of that item, luxury expenditure of that household type, and the price of that item. It is noteworthy that the price of an item affects its demand for luxury consumption only.

Block 10 Equations for household demand

$$\begin{aligned} x_{item_{km}} = & [1 - \text{ALPHA}_{I_{km}}] [q_{p_m} + aitemsub_{km}] \\ & + \text{ALPHA}_{I_{km}} \times [\text{luxexp}_m + aitemlux_{km} - pitem_k], \\ & k \in \text{ITM}, r \in \text{REG}, n \in \text{INC}, \quad (10.1) \end{aligned}$$

$$\begin{aligned} aitemlux_{km} = & aitemsub_{km} - \sum_{l \in \text{ITM}} (\text{DELTA}_{l_m} \times aitemsub_{lm}), \\ & k \in \text{ITM}, r \in \text{REG}, n \in \text{INC}, \quad (10.2) \end{aligned}$$

$$\begin{aligned} aitemsub_{km} = & aitem_{km} - \sum_{l \in \text{ITM}} (\text{VITEM}_{l_m} \times aitem_{lm}), \\ & k \in \text{ITM}, r \in \text{REG}, n \in \text{INC}, \quad (10.3) \end{aligned}$$

$$\begin{aligned} \text{utility}_m = & \text{luxexp}_m - q_{p_m} - \sum_{k \in \text{ITM}} (\text{DELTA}_{k_m} \times pitem_k), \\ & r \in \text{REG}, n \in \text{INC}, \quad (10.4) \end{aligned}$$

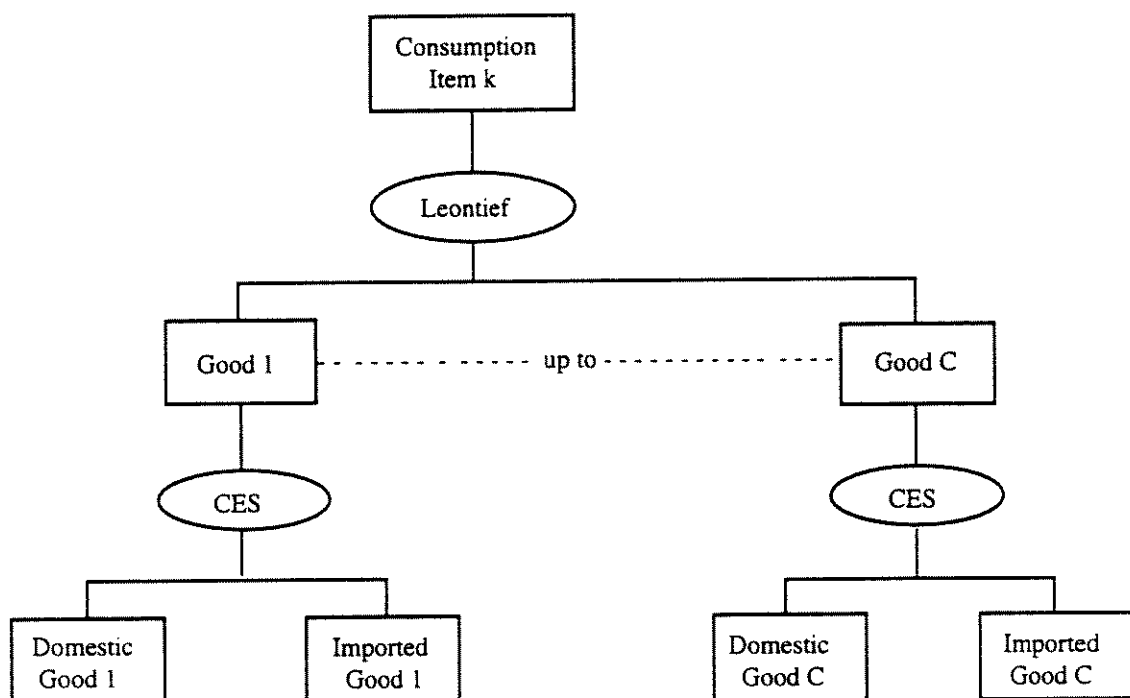
$$\begin{aligned} \text{chou}_m = & \frac{1}{\text{VITEM}_{k_m}} \sum_{k \in \text{ITM}} (\text{VITEM}_{k_m} \times \{xitem_{km} + pitem_k\}), \\ & r \in \text{REG}, n \in \text{INC}. \quad (10.5) \end{aligned}$$

In equation (10.3), $aitem$ is the taste-change variable represented by a change in the average budget share of the item. Equations (10.2) and (10.3) give default settings for the taste-change variables, $aitemlux_{km}$, and $aitemsub_{km}$. These equations allow the average budget shares to be shocked *via*, $aitem$, in a way that preserves the pattern of expenditure elasticities (see Horridge, 1993 for further details).

4.19 Demands for Commodities for Item Formation

Figure 4.26 shows the structure for the formation of consumption items. These items are assumed to be produced by inputs of domestic and imported commodities. The production function has the same nested structure as that which governs inputs to the production of new units of fixed capital. No primary factors are used directly as inputs to item formation.

Figure 4.26 Formation Structure of Consumption Items



The input demand equations (see Block 11) are derived from the solution to the two-parts cost minimisation problem. At the bottom level, the total cost of imported and domestic good i is minimised subject to the CES production function

$$X3ITEM_{ski} = CES(X3ITEM_{kis}), \quad k \in ITM, i \in COM, s \in SRC. \quad (4.19.1)$$

At the top level the total cost of commodity composites (in production of item k) is minimised subject to the Leontief production function

$$XITEM_{mk} = MIN(X3ITEM_{ski}), \quad k \in ITM. \quad (4.19.2)$$

The total demand for consumption item k , $XITEM_{mk}$, is an aggregation of demand for item k from all households (see Block 10 for equations determining items demand by household type). Equation (11.1) in Block 11 defines this aggregation in the percentage-change form (see example 9 in Table B1 in Appendix B for the conversion). The matrices $VITEM$ give the consumption of item k by household type m .

Block 11 Demand equations for formation of items

$$xitem\_m_k = \frac{1}{VITEM\_k m} \left(\sum_{r \in REG} \sum_{n \in INC} VITEM_{k m} \times xitem_{k m} \right), \quad k \in ITM, \quad (11.1)$$

$$x3item\_s_{ki} = xitem\_m_k, \quad k \in ITM, i \in COM, \quad (11.2)$$

$$pitem_k = \frac{1}{COMITEM\_is_k} \left(\sum_{i \in COM} COMITEM_{s_{ki}} \times p3item\_s_{ki} \right), \quad k \in ITM, \quad (11.3)$$

$$x3item_{kis} = x3item\_s_{ki} - \sigma COM3_i [p3_{is} - p3item\_s_{ki}], \quad k \in ITM, i \in COM, s \in SRC, \quad (11.4)$$

$$p3item\_s_{ki} = \frac{1}{COMITEM\_s_{ki}} \left(\sum_{s \in SRC} COMITEM_{kis} \times p3_{is} \right), \quad k \in ITM, i \in COM, \quad (11.5)$$

$$x3_{is} = \frac{1}{COMITEM\_k_{is}} \left(\sum_{k \in ITM} COMITEM_{kis} \times x3item_{kis} \right), \quad i \in COM, s \in SRC. \quad (11.6)$$

The equations in Block 11 describing the demand for source-specific inputs ($x3item_{kis}$) for item formation are similar to the equations covered in Block 8. Corresponding to the bottom-level nests, equations (11.4) determine demand for commodities, by source, for item formation. In these equations, $\sigma COM3_i$ represent elasticity of substitution of commodities from the two sources. Hence, changes in the relative price of commodity i by source affect their demand for item formation. Equation (11.2) corresponds to the top-level nest of Figure 4.26 and it states that the demand for composite commodity i is in direct proportion to the demand for item k .

Block 11 contains two price equations. Equations (11.3) determine the price of item k as the average cost of its production—a zero pure profit condition. The matrix, $COMITEM_{kis}$, is the data flow matrix of commodity i consumption, by source, for item k formation. In equation (11.5) the price of composite commodity i for item k formation ($p3item\_s_{ki}$), is the weighted average of prices of imported and domestic commodities for household consumption ($p3_{is}$).

Equation (11.6) in Block 11 aggregates the demands for commodities by source for item formation.

4.20 Exports Demand and Government Consumption

Equations (12.1) in Block 12 specify downward-sloping foreign demand schedules for exports. In levels, the equation read:

$$x4_i = FEQ_i \left[\frac{PE_i}{FEP_i} \right]^{EXP\_ELAST_i}, \quad i \in COM, (4.20.1)$$

where EXP_ELAST_i is a negative parameter—the constant elasticity of demand. These equations (12.1) state that export volumes, $x4_i$, are declining functions of their prices in foreign currency, PE_i . The shift variables, FEQ_i and FEP_i , allow for horizontal (quantity) and vertical (price) shifts in the demand schedules.

In Block 12, the export price equations state that the export price of commodity i , in local currency, is equal to the average cost of its supply—zero pure profit in exports. The average cost of export supply includes basic production cost, indirect tax and the cost of margin-goods while the variable, ϕ_i , is the exchange rate.

Block 12 Equations for exports demand and government consumption

$$x4_i - feq_i = EXP\_ELAST_i [pe_i - fep_i], \quad i \in COM, (12.1)$$

$$pe_i + \phi_i = \frac{1}{PUR_{4i}} \left((V4BAS_i + V4TAX_i) \times (p0dom_i + t4_i) + \sum_{m \in MAR} V4MAR_{im} [p0dom_i + a4mar_{im}] \right), \quad i \in COM, (12.2)$$

$$x5_{is} = chour_m + f5_{is} + f5_{tot}, \quad i \in COM, s \in SRC. (12.3)$$

In the model, equation (12.1) can be used flexibly. For example, for commodities in which export volumes and prices are determined by the government agreement, we might assume that the export elasticity is zero for these commodities, and then set $x4_i$ exogenously. Similarly, for all non-exported commodities, we can set their export elasticities to zero, and then

exogenously set their export quantities to zero. Thus, for these commodities, the export quantity-shift variables are determined endogenously.

For some of the commodities, for which we want to set an export-volume target, we might assume that $x4_i$ are given exogenously, and then the export tax will be calculated endogenously. Hence, by swapping exogenously given tax rates on exports, with endogenously defined export quantities, we can compute the changes in tax rates on exports required to meet the given targets of export volumes in the presence of some other policy shocks.

Equations (12.3) in Block 12 determine commodities' demand for government consumption by source. In these equations there are two shift variables: $f5_{tot}$, which allows an exogenous change in the demand for all commodities, and $f5_{is}$, which allows shift in the demand for a commodity from a source. It is assumed that government demand is in direct proportion to real private consumption in the absence of any exogenous shift in the government demand (when $f5_{tot}$ and $f5_{is}$ are all exogenously set to zero).

4.21 Demand for Margin-Goods

In the model, "margin commodities" are required to transport commodities from their production point (or port in the case of imports) to their consumption point.

Block 13 Equations of demands for margin-goods

$$x1_{mar_{isjm}} = x1_{isj} + a1_{mar_{isjm}}, \quad i \in COM, s \in SRC, j \in IND, m \in MAR, \quad (13.1)$$

$$x2_{mar_{isjm}} = x2_{isj} + a2_{mar_{isjm}}, \quad i \in COM, s \in SRC, j \in IND, m \in MAR, \quad (13.2)$$

$$x3_{mar_{ism}} = x3_{is} + a3_{mar_{ism}}, \quad i \in COM, s \in SRC, m \in MAR, \quad (13.3)$$

$$x4_{mar_{im}} = x4_i + a4_{mar_{im}}, \quad i \in COM, m \in MAR, \quad (13.4)$$

$$x5_{mar_{ism}} = x5_{is} + a5_{mar_{ism}}, \quad i \in COM, s \in SRC, m \in MAR. \quad (13.5)$$

The equations in Block 13 specify the demand for margin-goods on flows of commodities to: producers, investors, item producers, government; and for exports (from production point to the ports). These equations specify units of a margin-good required to bring a unit of commodity from production or supply point to the consumption point. In all the equations it is assumed that, in the absence of technical change, the demand for margin-goods is in direct proportion to the commodities flows with which the margins are associated. In equations (13.1) to (13.5) the variables a_{1mar} to a_{5mar} represent technical changes in the usage of margin-good on commodities flows to five user groups.

In all the equations in Block 13, there are margins on flows of both domestic and imported commodities to all users except for exports. Since all exports are produced domestically, there are no flows of imported commodities for exports and hence no margins on their flows.

For household consumption it is assumed that margins are on commodities flows that are used to produce items (which are consumed by the households) rather than on flows of items.

4.22 Purchasers' Prices

The equations in Block 14 define purchasers' prices for each of the four user groups: producers; investors; item producers; and government. Purchasers' prices are defined as the weighted sum of basic prices (average production cost), sales taxes and the costs of margin-goods. We refer to the sum of the basic price of a commodity and the sales-tax on it as the sale price of the commodity. Sales taxes are treated as *ad valorem* on basic values. The sales tax variables, t , in the linearised model represent percentage changes in the power of the taxes.

The equation for the power of tax, in the levels form, is defined as

$$T3_i = (1 + \text{TAXRATE3}_i), \quad i \in .\text{COM}, \quad (4.22.1)$$

where $TAXRATE3_i$ is the *ad valorem* tax rate on commodity i sale for item formation. We derive the equations of purchasers' prices from the following procedure. The purchasers' cost of commodity i from source s —say for item formation—is

$$X3_{is} \times P3_{is} = X3_{is} \times P0_{is} \times T3_{is} + \sum_{m \in MAR} X3MAR_{ism} \times P0DOM_{ism},$$

$i \in COM, s \in SRC, (4.22.2)$

where $X3_{is}$ is the purchased quantity of commodity i , from source s , for item formation, and $P3_{is}$ is the purchasers' price of the commodity. In percentage-change form this is:

$$(p3_{is} + x3_{is}) = \frac{1}{PUR3_{is}} \left(\sum_i (V3BAS_{is} + V3TAX_{is}) [p0_{is} + t3_{is} + x3_{is}] \right. \\ \left. + \sum_{m \in MAR} (V3MAR_{ism} [p0dom_m + x3mar_{ism}]) \right),$$

$i \in COM, s \in SRC, (4.22.3)$

where the coefficients are shares of sale values (basic value plus sales taxes) of commodity i , and the share of cost of margin-goods m in the purchasers' prices. Using Equation (13.3) from Block 13 to substitute $x3mar_{ism}$, we can cancel out the term $x3_{is}$ to obtain

$$p3_{is} = \frac{1}{PUR3_{is}} \sum_{i \in COM} \left([V3BAS_{is} + V3TAX_{is}] \times \{t3_{is} + p0_{is}\} \right. \\ \left. + \sum_{m \in MAR} V3MAR_{ism} \{p0dom_m + a3mar_{ism}\} \right),$$

$i \in COM, s \in SRC, j \in IND. (4.22.4)$

Using the above discussed procedure we can derive the purchasers' price equations for producers, investors and the government, which are stated in Block 14. The matrices $PUR1$ to $PUR5$ and $V1BAS$ to $V5BAS$ contain data flows on costs of commodities sales to five consumer categories in purchasers' prices and basic prices respectively. $V1TAX$ to $V5TAX$ matrices contains taxes on the sales which are paid by these five groups while $V1MAR$ to $V5MAR$ contains margins' costs on sales of the commodities (see Section 4.5 on input-output data base).

Block 14 Equations for Purchasers' prices

$$p0_{is} = p0_{dom_i}, \quad s = \text{domestic}, i \in \text{COM}, \quad (14.1)$$

$$p0_{is} = p0_{imp_i}, \quad s = \text{imported}, i \in \text{COM}, \quad (14.2)$$

$$p1_{isj} = \frac{1}{PUR1_{isj}} \left([V1BAS_{isj} + V1TAX_{isj}] \times \{p0_{is} + t1_{isj}\} + \sum_{m \in \text{MAR}} (V1MAR_{isjm} \{p0_{dom_m} + a1_{mar_{isjm}}\}) \right), \\ i \in \text{COM}, s \in \text{SRC}, j \in \text{IND}, \quad (14.3)$$

$$p2_{isj} = \frac{1}{PUR2_{isj}} \left([V2BAS_{isj} + V2TAX_{isj}] \times \{p0_{is} + t2_{isj}\} + \sum_{m \in \text{MAR}} (V2MAR_{isjm} \{p0_{dom_m} + a2_{mar_{isjm}}\}) \right), \\ i \in \text{COM}, s \in \text{SRC}, j \in \text{IND}, \quad (14.4)$$

$$p3_{is} = \frac{1}{PUR3_{is}} \left([V3BAS_{is} + V3TAX_{is}] \times \{p0_{is} + t3_{is}\} + \sum_{m \in \text{MAR}} V3MAR_{ism} \{p0_{dom_m} + a3_{mar_{ism}}\} \right), \\ i \in \text{COM}, s \in \text{SRC}, \quad (14.5)$$

$$p5_{is} = \frac{1}{PUR5_{is}} \left([V5BAS_{is} + V5TAX_{is}] \times \{p0_{is} + t5_{is}\} + \sum_{m \in \text{MAR}} V5MAR_{ism} \{p0_{dom_m} + a5_{mar_{ism}}\} \right), \\ i \in \text{COM}, s \in \text{SRC}, \quad (14.6)$$

$$p0_{imp_i} = pm_i + phi_i + tm_i, \quad i \in \text{COM}. \quad (14.7)$$

The first two equations in Block 14 map basic prices of domestic and imported commodity i , on basic price variables, $p0_{is}$, which represent basic price of commodity i by its source.

Equation (14.7) defines the basic price of imported commodity i , as the local currency value of its import cost, plus the import tax on it. In the levels form it is:

$$P0IMP_i = PM_i \times PHI_i \times TM_i, \quad (4.22.5)$$

where PM_i is the CIF value of imported commodity i , in foreign currency; PHI is the nominal exchange rate; and TM_i is the power of the import tax on commodity i (see Appendix B for converting this equation into percentage change form).

4.23 Indirect Taxes

Block 15 Equations for indirect taxes

$$t1_{isj} = t_{is} + t1_{isj} + t0 + t1_{eij}, \quad i \in \text{COM}, s \in \text{SRC}, j \in \text{IND}, \quad (15.1)$$

$$t2_{isj} = t_{is} + t2_{isj} + t0 + t2_{eij}, \quad i \in \text{COM}, s \in \text{SRC}, j \in \text{IND}, \quad (15.2)$$

$$t3_{is} = t_{is} + t3_{is} + t0 + t3_{ei}, \quad i \in \text{COM}, s \in \text{SRC}, \quad (15.3)$$

$$t5_{is} = t_{is} + t5_{is} + t0, \quad i \in \text{COM}, s \in \text{SRC}. \quad (15.4)$$

In Block 15, equations (15.1) to (15.4) define indices of the power of sales taxes for producers, investors, items' producers, and the government respectively. The sales-tax rates on household consumption, $t3_{is}$, are assumed to be on commodity sales for item formation which are demanded by households only. The sales-tax rates are treated as *ad valorem* on basic value, with the sales-tax variables defined as power of taxes rather than tax rates. The power of a tax is defined in levels form as

$$T_i = (1 + \text{TAXRATE}_i), \quad i \in \text{COM}, \quad (4.23.1)$$

where TAXRATE_i is the *ad valorem* tax rate on commodity i .

In Block 15, an index of the power of sales tax for each user category is defined using 4 types of sales-tax variable representing:

- commodity-and-source specific sales taxes, t_{is} ;
- user-specific sale-taxes such as $t1$ for producers and $t2$ for investors;
- uniform tax rate on all users and all commodities, $t0$; and
- user-and-commodity specific taxes such as, $t1_{eij}$.

The default rule for power of sales tax for a user category in level form is:

$$TU_{is} = T_{is} \times TU_{is} \times T0 \times TU_{Eij}, \quad i \in \text{COM}, s \in \text{SRC}, \quad (4.23.2)$$

while U stands for user category (1, 2, 3 or 5). Equations (15.1) to (15.4) are the percentage-change form of the above equation (see Appendix B for the conversion rules). Of the four types of tax variable, the uniform tax rate

variable (t_0) and the user-and-commodity-specific tax rate variables (TU_{Eij}) need some explanations. In the following paragraphs we discuss these two types of tax.

Normally we assume that the tax rates are given exogenously, and the model computes total indirect tax revenues for a policy shock. However, in some simulations, we might wish to carry out a tax revenue-neutral experiment. In such experiments, the tax variable, t_0 , is used as an instrument. It determines a percentage change in all sales tax rates that allows total tax revenues to remain at their exogenously fixed level. Hence, in tax revenue-neutral simulations, we swap the t_0 variable with the total indirect tax revenue variable (which is defined in Section 4.27).

The variables $t1_{Eij}$, $t2_{Eij}$, and $t3_{Ei}$ represent commodity-and-user-specific sales taxes. In Chapter 2 we discussed user-discriminating sales taxes on natural gas and electricity. For example, tax rates on electricity sales to agricultural industries differ from the tax rates on sales to manufacturing industries. Similarly tax on electricity sales to households is different from that on sales to industries. The variables $t3_{Eij}$ represent commodity-and-user-specific taxes for households. These commodity-and-user-specific tax variables are introduced to simulate the impact of removing the user-discriminating taxes on energy products. Though these commodity-and-user-specific taxes are levied only on selected commodities, we have introduced them for all commodities for the sake of uniformity.

4.24 Modelling of Regulated Prices

In Section 4.22 we discussed the equations determining purchaser's prices. We assume that the purchaser's price of commodity i is the sum of its sales price (basic price plus the exogenously given taxes on it) and the costs of margins on its supply. While the tax rates are normally given exogenously, the other two components of purchasers' prices are determined endogenously. However, as discussed in Chapter 2, the basic prices of the three major energy commodities are set by the government and are altered occasionally. Hence

changes in the production costs of these commodities will not immediately pass through to the purchaser's prices. We interpret the difference between the production costs of a commodity (both fixed and variable costs) and its regulated basic price, as an implicit tax component which varies as the basic price of the commodity changes. Thus, the government indirectly changes the tax rates on these commodities.

In the application of GE-PAK in this thesis we have assumed that all prices are determined by the market at the margin. That is, we have held implicit tax rates (rather than purchaser's prices) exogenous in our reported simulations. However, in the model we have introduced an equation that can be switched on to make the regulated prices exogenous³. The equation, then, determines the changes in the power of tax rates for these commodities. In the set of equations for indirect taxes, we include the following equations which give a default rule to determine the source-specific sales tax on commodities that have regulated prices.

Block 16 Tax rate equations for commodities with regulated prices

$$fp0pub_{as} = t_{as} + p0_{as}, \quad a \in ADM, s \in SRC, (16.1)$$

where ADM is a subset of commodities that have regulated prices. In this equation, the variables $fp0pub_{as}$ represent shift in the basic prices of commodities by source. Equation (16.1) states that a shift in the sale price of commodity a , from source s , is the sum of its basic price plus the commodity-and-source-specific sales-tax on it. For any change in the production cost of commodity a , with fixed basic price (*i.e.*, if $fp0pub_{as}$ is exogenous while $t0_{as}$

³An example of such an experiment can be seen in the study by Sarkar and Kadekodi (1988) on energy pricing issues in India. In this study, they analysed the effects of increasing energy prices in two alternative scenarios. In one scenario one price of an energy product is increased— say Coal— but all other energy prices remain unchanged. In the latter public sector industries, the profit rates are adjusted. In the second scenario all other energy prices are determined by the market when the same shock is applied.

become endogenous), there is an off-setting change in its commodity-and-source-specific sales-tax ($t0_{as}$) determined by equation (16.1).

In the following paragraphs we show that the incorporation of this default rule makes purchasers' prices independent of the basic prices; now purchasers' prices are determined by the exogenously given shift in their sale prices ($fp0pub_{as}$), some user-and-industry-specific sales taxes, and their margin costs.

First we replace equation (16.1) in an equation, from Block 4, that determines tax index—say for household consumption goods—and arrive at the following tax index in the subset ADM for households.

$$t3_{as} = fp0pub_{as} - p0_{as} + t3 + t0 + t3\_e_a \quad a \in ADM, s \in SRC. (4.24.1)$$

As discussed in Section 4.22, the purchaser's prices are defined as the sum of the sales value plus the margins cost. We rewrite the equations of purchasers' prices for the consumer as:

$$p3_{as} = \frac{1}{PUR3_{as}} ([V3BAS_{as} + V3TAX_{as}] \times [p0_{as} + t3_{as}] + \sum_{m \in MAR} V3MAR_{asm} \times mar3cost_{asm}), \quad a \in ADM, s \in SRC, (4.24.2)$$

where $mar3cost$ is the margin cost. By substituting the $t3_{as}$ from (4.24.1) into the above equation we obtain:

$$p3_{as} = \frac{1}{PUR3_{as}} ([V3BAS_{as} + V3TAX_{as}] \times (p0_{as} + fp0pub_{as} - p0_{as} + t3 + t0 + t3\_e_a) + \sum_{m \in MAR} V3MAR_{asm} \times marg3cost_{as}), \quad a \in ADM, s \in SRC. (4.24.3)$$

Consequently the purchasers' prices of commodities that have regulated prices are effectively determined by shift in their regulated sale-prices ($fp0pub$), some exogenously given user-specific and user-commodity-specific sales tax on them and the margin costs.

Equation (16.1) can be used flexibly. If we assume that there is no regulation on the price of commodities in subset ADM, we can set commodity-

source-specific sales taxes on these commodities exogenously. In this case endogenously determined shift variables, $fp0_{pub}$, will show the necessary change in the sale prices of all commodities in set ADM. These shift variables, however, will not affect any other endogenously determined variable as the former variables do not appear in any other equation.

4.25 Market Clearing Equations for Commodities

Block 17 below includes market-clearing equations for domestic commodities and equations which compute the aggregate demand for imports. Equations (17.1) equate aggregate demand for margin-goods to their total production. Margin-goods are supplied only from domestic sources and are used both as intermediate inputs by industries, and as a margin on the supply of imported and domestic commodities to five types of consumer. Equations (17.2) equate the total demand for non-margin commodities from all consumer categories to their production. The SALE matrix contains aggregate basic value or production costs of domestic commodities. Equation (17.3) computes aggregate usage of imported commodities. The data matrix VOIMP contains the import cost of commodities; aggregated for all consumer categories (see Section 4.5 on input-output data base). We assume that world prices of imports are given exogenously and, hence, elasticities of imports supply are infinite.

Block 17 Market clearing equations for commodities

$$\begin{aligned}
 x0_{dom\ m} = & \frac{1}{SALES_j} \left[\sum_{j \in IND} V1BAS_{mlj} \times x1_{mlj} + \sum_{j \in IND} V2BAS_{mlj} \times x2_{mlj} \right. \\
 & + V3BAS_{ml} \times x3_{ml} + V4BAS_m \times x4_m \\
 & + V5BAS_{ml} \times x5_{ml} \\
 & + \sum_{i \in COM} \left[V4MAR_{im} \times x4_{mar_{im}} + \sum_{s \in SRC} V3MAR_{ism} \times x3_{mar_{ism}} \right. \\
 & + \sum_{s \in SRC} V5MAR_{ism} \times x5_{mar_{ism}} + \sum_{s \in SRC} \sum_{j \in IND} V1MAR_{ismj} \times x1_{mar_{ismj}} \\
 & \left. \left. + \sum_{s \in SRC} \sum_{j \in IND} V2MAR_{ismj} \times x2_{mar_{ismj}} \right] \right], \\
 & l = \text{domestic, } m \in MAR, (17.1)
 \end{aligned}$$

$$x0dom_i = \frac{1}{SALES_j} \left[\sum_{j \in IND} V1BAS_{ij} \times x1_{ij} + \sum_{j \in IND} V2BAS_{ij} \times x2_{ij} + V3BAS_{il} \times x3_{il} + V4BAS_i \times x4_i + V5BAS_{il} \times x5_{il} \right],$$

l=domestic, i ∈ NONMAR, (17.2)

$$x0imp_i = \frac{1}{VOIMP_j} \left[\sum_{j \in IND} V1BAS_{ij} \times x1_{ij} + \sum_{j \in IND} V2BAS_{ij} \times x2_{ij} + V3BAS_{il} \times x3_{il} + V5BAS_{il} \times x5_{il} \right],$$

l=imported, i ∈ COM. (17.3)

4.26 Demands for Primary Factors by Type

Equations in Block 18 (below) add up demands for primary factors in industries. Equation (18.1) computes aggregate labour demands by region and skill from all industries (lambda_{rp}) while equations (18.2) and (18.3) compute total usage of capital (x1cap_{jc}) and land (x1lnd_{jd}). The coefficients V1LAB, V1CAP and V1LND are data matrices containing wage bills or rental values for these factors (see the data base description in Section 4.5). Equation (18.4) gives total labour demand by region (lambda_{pr}) and equation (18.5) determines total labour demand by profession (lambda_{rp}). In Section 4.33 we have discussed market clearing conditions for factors by setting these demands equal to their aggregate supply from institutions. We have also discussed there the factor market closure in the short-run.

Block 18 Demand equations for aggregate primary factors

$$\lambda_{rp} = \frac{1}{V1LAB_{jr}} \sum_{j \in IND} V1LAB_{rj} \times x1_{rj}, \quad r \in REG, p \in PRF, (18.1)$$

$$x1cap_{jc} = \frac{1}{V1CAP_{jc}} \sum_{j \in IND} V1CAP_{cj} \times x1_{cj}, \quad c \in CAP, (18.2)$$

$$x1lnd_{jd} = \frac{1}{V1LND_{jd}} \sum_{j \in IND} V1LND_{dj} \times x1_{dj}, \quad d \in LND, (18.3)$$

$$\lambda_{pr} = \frac{1}{V1LAB_{pj}} \sum_{p \in PRF} V1LAB_{rp} \times \lambda_{rp}, \quad r \in REG, (18.4)$$

$$\lambda_{rp} = \frac{1}{V1LAB_{rp}} \sum_{r \in REG} V1LAB_{rp} \times \lambda_{rp}, \quad p \in PRF. (18.5)$$

4.27 Aggregate Demand for Final Consumption, Exports, Imports and Indirect Tax Revenues

The equations in Block 19 compute some macroeconomic variables such as total exports, imports, private and public consumption, *etc.* In the next section we use these macro variables to define GDP from the income and expenditure sides. Equations (19.1) and (19.3) compute aggregate exports and export volume. The aggregation procedure is simple. For example, the total export bill in levels is the sum of all export quantities multiplied by corresponding prices (see Appendix B for percentage change form conversion). Similarly, equations (19.2) and (19.4) compute aggregate import volume and the import bill. In Block 19, the variables $xik3$, $xi4$, xim and $xi5$ are the price indices defined for the four consumer categories. They are discussed in Section 4.30. Equation (19.5) computes real consumption for each household category ($chour_m$) by deflating the nominal consumption of each group by its price index ($xiitem_m$).

Equation (19.6) computes real *per capita* consumption for each household category. In the levels form, the *per capita* consumption for a household category is defined as:

$$PERCON_m = \frac{CHOUR_m}{Q_{-p_m} \times HSIZE_m}$$

where $HSIZE_m$ is number of persons per household and Q_{-p_m} is number of households in each household category. Equation (19.6) is the linear form of the above equation. Since GE-PAK determines consumption by types of household, equation (19.7) computes total real private consumption by adding up real consumption in each household category. Similarly, equation (19.8) computes total nominal private consumption.

Block 19 Equations of Aggregate Demand for Final Consumption, Exports, Imports and Indirect Tax revenues

$$exp = \frac{1}{PUR4\_I} \sum_{i \in COM} PUR4_i \times [pe_i + x4_i], \quad (19.1)$$

$$\text{imp} = \frac{1}{\text{VOIMP}_i} \sum_{i \in \text{COM}} \text{VOIMP}_i \times [\text{pm}_i + \text{x0imp}_i], \quad (19.2)$$

$$\text{expvol} = \text{exp} + \text{phi} - \text{xi4}, \quad (19.3)$$

$$\text{impvol} = \text{imp} + \text{phi} - \text{xim}, \quad (19.4)$$

$$\text{chour}_m = \text{chou}_m - \text{xiitem}_m, \quad r \in \text{REG}, n \in \text{INC}, \quad (19.5)$$

$$\text{perconr}_m = \text{chour}_m - \text{q}_m - \text{hsize}_m, \quad r \in \text{REG}, n \in \text{INC}, \quad (19.6)$$

$$\text{chour}_m = \frac{1}{\text{VITEM}_{km}} \sum_{r \in \text{REG}} \sum_{n \in \text{INC}} \text{VITEM}_{km} \times \text{chour}_m, \quad (19.7)$$

$$\text{chou}_m = \frac{1}{\text{VITEM}_{km}} \sum_{r \in \text{REG}} \sum_{n \in \text{INC}} \text{VITEM}_{km} \times \text{chou}_m, \quad (19.8)$$

$$\text{inv} = \text{invr} + \text{xi2}, \quad (19.9)$$

$$\text{invr} = \frac{1}{\text{PUR2}_{isj}} \sum_{j \in \text{IND}} \text{PUR2}_{isj} \times y_j, \quad (19.10)$$

$$\text{oth} = \text{othr} + \text{xi5}, \quad (19.11)$$

$$\text{oth} = \frac{1}{\text{PUR5}_{is}} \sum_{i \in \text{COM}} \sum_{s \in \text{SRC}} \text{PUR5}_{is} \times x_{5is}, \quad (19.12)$$

$$\text{labrev} = \frac{1}{\text{VILAB}_{rpj}} \sum_{j \in \text{IND}} \sum_{r \in \text{REG}} \sum_{p \in \text{PRF}} \text{VILAB}_{rpj} \times (\text{p1lab}_{rpj} + \text{x1lab}_{rpj}), \quad (19.13)$$

$$\text{caprev} = \frac{1}{\text{VICAP}_{cj}} \sum_{j \in \text{IND}} \sum_{c \in \text{CAP}} \text{VICAP}_{cj} \times (\text{p1cap}_{cj} + \text{x1cap}_{cj}), \quad (19.14)$$

$$\text{lnndrev} = \frac{1}{\text{VILND}_{dj}} \sum_{j \in \text{IND}} \sum_{d \in \text{LND}} \text{VILND}_{dj} \times (\text{p1lnd}_{dj} + \text{x1lnd}_{dj}), \quad (19.15)$$

$$\text{octrev} = \frac{1}{\text{VIOCT}_j} \sum_{j \in \text{IND}} \text{VIOCT}_j \times (\text{p1loct}_j + \text{x1loct}_j), \quad (19.16)$$

$$\begin{aligned} \text{tlrev}_{isj} = \frac{1}{\text{VITAX}_{isj}} \sum_{i \in \text{COM}} \sum_{s \in \text{SRC}} \sum_{j \in \text{IND}} & (\text{VITAX}_{isj} \times \{ \text{p0}_{is} + \text{x1}_{isj} \} \\ & + [\text{VITAX}_{isj} + \text{VIBAS}_{isj}] \times \text{tl}_{isj}), \end{aligned} \quad (19.17)$$

$$t2rev\_isj = \frac{1}{V2TAX\_isj} \sum_{i \in COM} \sum_{s \in SRC} \sum_{j \in IND} (V2TAX\_isj \times \{ p0_{is} + x2_{isj} \} + [V2TAX\_isj + V2BAS\_isj] \times t2_{isj}), \quad (19.18)$$

$$t3rev\_is = \frac{1}{V3TAX\_is} \sum_{i \in COM} \sum_{s \in SRC} (V3TAX\_is \times \{ p0_{is} + x3_{is} \} + [V3TAX\_is + V3BAS\_is] \times t3_{is}), \quad (19.19)$$

$$t4rev\_i = \frac{1}{V4TAX\_i} \sum_{i \in COM} (V4TAX\_i \times \{ p0_{dom_i} + x4_i \} + [V4TAX\_i + V1BAS_i] \times t4_i), \quad (19.20)$$

$$t5rev\_is = \frac{1}{V5TAX\_is} \sum_{i \in COM} \sum_{s \in SRC} (V5TAX\_is \times \{ p0_{is} + x5_{is} \} + [V5TAX\_is + V5BAS\_is] \times t5_{is}), \quad (19.21)$$

$$tmrev\_i = \frac{1}{V0TAR\_i} \sum_{i \in COM} V0TAR_i \{ pm_i + phi + x0_{imp_i} \} + \sum_{i \in COM} IMPORTS_i \times tm_i, \quad (19.22)$$

$$t0rev = \frac{1}{V0TAX} (V1TAX\_isj \times t1rev\_isj + V2TAX\_isj \times t2rev\_isj + V3TAX\_is \times t3rev\_is + V4TAX\_i \times t4rev\_i + V5TAX\_i \times t5rev\_is + V0TAR \times tmrev\_i + V1OCT\_j \times octrev). \quad (19.23)$$

Equation (19.10) computes total real investments which is a sum of real investments in all industries, while equation (19.9) calculates total nominal investments. In equation (19.12) add up commodities consumed by government while equation (19.11) computes this aggregate government consumption in real terms using the its price index, $xi5$.

Equations (19.13) to (19.15) compute the total wage bills of labour or rental values of capital and land. These aggregates are computed using prices of, and demand for, these factors. Equation (19.16) computes total 'other costs'. We treat this cost as a production tax or subsidy. Hence total 'other costs' is treated as government revenue which is then added to the total indirect tax revenues given in equation (19.23). Equations (19.17) to (19.21) compute indirect sales tax revenues paid by four consumer categories: producers; investors; items' producers; and government, while equation (19.22) computes import tax revenues. The total indirect tax revenues are computed in equation (19.23).

4.28 GDP and the Balance of Trade

In Block 20, equation (20.1) computes the trade balance in nominal terms (*i.e.*, billions of Rs). We define the trade balance as the difference between aggregate exports and imports. The percentage change in exports or imports, when multiplied by the corresponding values of base year, gives changes in nominal terms. We divide this value by 1000 to arrive at billions of Rs.

Equation (20.2) computes GDP from the expenditure side which is sum of: private consumption; investment expenditure; government consumption; and exports less imports. Each of these components is computed in Block 19. In this equation the coefficients are the base-year values of these components while GDPEXP is their sum. For example, the coefficient VITEM_km is the sum of the household consumption matrix, and PUR4_i is total exports. Equation (20.4) computes real GDP using the GDP deflator, xigdp.

Equations (20.5) to (20.7) compute total labour, capital and land stock.

Block 20 Equations for GDP and other macro-economic indicators

$$\text{delB} = (\text{PUR4}_i \times \text{exp} - \text{V0IMP}_i \times \text{imp}) \times 100.0 / 1000.0, \quad (20.1)$$

$$\text{gdpexp} = \frac{1}{\text{GDPEXP}} \left(\text{VITEM\_km} \times \text{chou\_m} + \text{PUR2\_isj} \times \text{inv} \right. \\ \left. + \text{PUR5\_is} \times \text{oth} \right. \\ \left. + \text{PUR4}_i \times (\text{exp} + \text{phi}) - \text{V0IMP}_i \times (\text{imp} + \text{phi}) \right), \quad (20.2)$$

$$\text{gdpinc} = \frac{1}{\text{GDPINC}} \left(\text{V1LND\_dj} \times \text{lndrev} + \text{V1CAP\_cj} \times \text{caprev} \right. \\ \left. + \text{V1LAB\_rpj} \times \text{labrev} \right. \\ \left. + \text{V0TAX} \times \text{t0rev} \right), \quad (20.3)$$

$$\text{gdpreal} = \text{gdpexp} - \text{xigdp}, \quad (20.4)$$

$$\text{x1cap\_cj} = \frac{1}{\text{V1CAP\_cj}} \sum_j \text{V1CAP\_cj} \times \text{x1cap\_cj}, \quad (20.5)$$

$$\text{x1lab\_rpj} = \frac{1}{\text{V1LAB\_rpj}} \sum_j \text{V1LAB\_rpj} \times \text{x1lab\_rpj}, \quad (20.6)$$

$$\text{x1lnd\_dj} = \frac{1}{\text{V1LND\_dj}} \sum_j \text{V1LND\_dj} \times \text{x1lnd\_dj}. \quad (20.7)$$

4.29 Investment Allocation by Industries and Rates of Return

Block 21 Equations for Investment Allocation

$$r0_j = QCOEF_j \times [p1cap\_c_j - p2\_is_j], \quad j \in IND, \quad (21.1)$$

$$r0_j - r0t = BETA\_R_j \times [x1cap\_c_j - x1cap\_c_j] + fr0_j, \quad j \in IND, \quad (21.2)$$

$$x1cap\_c_j = INV\_ELAST_j \times y_j + fx1cap\_c_j, \quad j \in IND. \quad (21.3)$$

Dixon *et al.* (1982) has defined a theory of investment allocation across industry for ORANI. We have adopted their investment equations in our model. Equation (21.1) defines the rate of return ($r0_j$) on capital (net of depreciation) in industry j . In levels, this is the ratio of the rental price of capital ($P1CAP\_c$) to the supply price ($P2\_is$) minus the rate of depreciation. Hence, the coefficient $QCOEF_j$ is the ratio of the gross to the net rate of return. The total capital stock, $X1CAP\_c_j$ is allocated across industries by a function given in equation (21.2). The function states that the change in the net rate of return in an industry (relative to the economy-wide rate) is a positive function of the change in the industry's capital stock (relative to the economy-wide stock). According to Horridge *et al.* (1993) this function can be interpreted as a risk-related relationship with relatively fast- (slow-) growing industries requiring premium (accepting discounts) on their rates of return. The parameter $BETA\_R_j$ specifies the strength of this relationship. Further, the variables $fr0_j$ allow exogenous shifts in industries rate of return. Equation (21.3) translates the demand for capital stock in industry j ($x1cap\_c_j$) into investment funds required by industry j (y_j). The elasticity of capital stock demand in industry j with respect to its investment is represented by the coefficient INV_ELAST_j . The variable $fx1cap\_c_j$ allows exogenous shifts in the capital stock of industry j . The model allows us to set investment by industries exogenously. In such simulations the shift variables $fx1cap\_c_j$ are determined endogenously to match the demand for capital stock in industries with their exogenously given investments (see Section 19 in Dixon *et al.*, 1982 for details or Horridge *et al.*, 1993).

4.30 Price Indices

Block 22 (above) gives equations to compute price indices for four types of user, two import price indices, a factor price index and a GDP deflator. In the levels form the consumer price indices are defined as the weighted-average of commodity prices for a consumer category. The weights are the shares of commodities in total expenditure incurred by that consumer category (see conversion rule in Table B1 in Appendix B). Equations (22.1) to (22.4) compute the price indices for investments, private consumption, consumption by household types, and government consumption.

Equation (22.1) states that investment price index is the weighted sum of prices of investment goods. The weights are shares of commodities in total investments. Similarly, xi3 is a price index for commodity-inputs into item formation, and xi5 is a price index for government consumption.

Block 22 Equations of price indices

$$xi2 = \frac{1}{PUR2\_isj} \sum_{i \in COM} \sum_{s \in SRC} \sum_{j \in IND} PUR2_{isj} \times p2_{isj}, \quad (22.1)$$

$$xi3 = \frac{1}{PUR3\_is} \sum_{i \in COM} \sum_{s \in SRC} PUR3_{is} \times p3_{is}, \quad (22.2)$$

$$xiitem_m = \frac{1}{VITEM\_k_m} \sum_{k \in ITM} VITEM_{k_m} \times pitem_k, \quad r \in REG, n \in INC, \quad (22.3)$$

$$xi5 = \frac{1}{PUR5\_is} \sum_{i \in COM} \sum_{s \in SRC} PUR5_{is} \times p5_{csis}, \quad (22.4)$$

$$xi4 - phi = \frac{1}{PUR4\_i} \sum_{i \in COM} PUR4_i \times pe_i, \quad (22.5)$$

$$xim - phi = \frac{1}{V0IMP\_i} \sum_{i \in COM} V0IMP_i \times pm_i, \quad (22.6)$$

$$ximp0 = \frac{1}{IMPORTS\_i} \sum_{i \in COM} IMPORTS_i \times p0_{imp_i}, \quad (22.7)$$

$$xigdp = \frac{1}{GDPEXP} (PUR2\_isj \times xi2 + PUR3\_is \times xi3 + PUR4\_i \times xi4 + PUR5\_is \times xi5 - V0IMP\_i \times xim), \quad (22.8)$$

$$xifac = \frac{1}{\sum_{j \in IND} V1PRM_j} \sum_{j \in IND} V1PRM_j \times p1prm_j . \quad (22.9)$$

Equations (22.3) compute price indices for 14 types of household; by region and income groups, because the consumption patterns of these households are not uniform. Hence the prices of items in equations (22.3) are weighted by the shares of items in total consumption of a household type. Equations (22.5) and (22.6) compute indices of foreign currency prices of exports and imports. Equation (22.7) computes the price index of imports inclusive of taxes on them. Using these price indices we compute an index for the GDP (expenditure) deflator in equation (22.8). Price index for a user group is weighted by the share of this group in the total GDP expenditure. Equation (22.9) computes the factor price index ($xifac$) which is a weighted-average of primary-factors price indices of industries ($p1prm_j$); the weights are the shares of industries in the aggregate primary-factors wage bill.

4.31 Income Mapping Data Base

Figure 4.27 shows the data flows to represent institutional income by source. The rows in Figure 4.27 show four types of institution:

- households,
- corporations,
- government, and
- ROW.

The columns of Figure 4.27 show seven sources of income, as follows.

- (1) Labour is owned by households and its wages are received by them.
- (2) Capital is owned by, and its rents accrue to, all four institutions.
- (3) Land is owned by, and its rent accrue to, all four institutions.
- (4) Households make transfer-payments to other households, and make transfer-payments to the government in the form of direct taxes. Hence, household transfers are sources of income for households and for government.
- (5) Corporations pay dividends to their shareholders (households and the government) and pay corporate tax to the government.

- (6) Government makes transfer payments such as pensions to households.
- (7) Remittances from ROW are received by households. These remittances are the money sent by Pakistani workers from overseas. Since these payments are made for services which have no contribution in GDP we consider them transfer payments.

Figure 4.27 Data Base for Income Mapping of Institutions

		1	2	3	4	5	6	7
		Sources of Income						
		Labour	Capital	Land	House-holds	Corpora-tions	Gover-nment	Rest of the World
Institut-ions	Size	PRF	CAP	LND	REG × INC	COR	GOV	ROW
House-holds HOU	↑ REG × INC × PRF ↓	VYHOU LAB (r,n,p)	VYHOU CAP (r,n,c)	VYHOU LND (r,n,d)	VYHOU HOU (r,n,r,n)	VYHOU COR (r,n,o)	VYHOU GOV (r,n)	VYHOU ROW (r,n)
Corpora-tions COR	↑ CORP ↓		VYCOP CAP (o,c)	VYCOP LND (o,d)				
Govern-ment GOV	↑ 1 ↓		VYGOV CAP (c)	VYGOV LND (d)	VYGOV HOU (r,n)	VYGOV COR (o)		
Rest of the World ROW	↑ 1 ↓		VYROW CAP (c)	VYROW LND (d)				

		V1LAB (r,p)	V1CAP (c)	V1LND (d)				

In Figure 4.27, the first row gives the names of the data matrices containing household income (VYHOU) from seven sources. The matrices VYCORCAP and VYCORLND in the second row are matrices of corporation income from two sources. The government receives income from four sources, its income matrices are listed in the third row. The ROW owns some capital and land in Pakistan. Its income from the two sources is given in the VYROWCAP and VYROWLND matrices.

Figure 4.28 Data Matrices of Income and Savings of Institutions

		Institution Income	Institution Savings
Institutions	Size		
Households HOU	$\uparrow$ $\text{REG} \times \text{INC}$ $\downarrow$	VYHOU_m	VSAVHOU_{rp}
Corporations COR	$\uparrow$ CORP $\downarrow$	VYCOR_o	VSAVCOR_o
Government GOV	$\uparrow$ 1 $\downarrow$	VYGOV	VSAVGOV
Rest of the World ROW	$\uparrow$ 1 $\downarrow$	VYROW	VSAVROW

In Figure 4.28 we list the names of data matrices which contain total incomes and savings of each type of institutions. For example VYHOU_m contains total income of households in a household category. In the following Subsections we discuss the equations that determine income by sources and assemble them to compute total income of each institution.

4.32 Price Indices of Primary Factors by Type

Block 23 (below) contains equations determining price indices for labour, capital and land. Equations (23.1) compute labour wage indices for 4 types of labour. These wage indices are defined for two professional categories of rural and urban labour. Each wage index is defined as the weighted-average unit cost of labour in industries for a category. The weights in equations (23.1) are the wage-bill shares of industries in the total wage-bill for a labour type in all industries.

Block 23 Equations for prices indices of primary factors by type for income mapping

$$p_{lab\_jr} = \frac{1}{V_{LAB\_jr}} \sum_{j \in IND} V_{LAB\_rj} \times p_{lab\_rj}, \quad r \in REG, p \in PRF, (23.1)$$

$$p_{cap\_jc} = \frac{1}{V_{CAP\_jc}} \sum_{j \in IND} V_{CAP\_cj} \times p_{cap\_cj}, \quad c \in CAP, (23.2)$$

$$p_{lnd\_jd} = \frac{1}{V_{LND\_jd}} \sum_{j \in IND} V_{LND\_dj} \times p_{lnd\_dj}, \quad d \in LND. (23.3)$$

Similar to the equations for wage indices, equations (23.2) define the price indices for 6 types of capital. In each industry, capital is a sum of 6 types of capital:

- non-corporate capital which is owned by households;
- private corporate capital that is owned by private corporations;
- public corporate capital that is owned by public corporations;
- government capital that is owned by government;
- capital in dwellings that is also owned by households; and
- ROW capital which is owned by foreigners.

The distribution patterns of these 6 types of capital across industries are not uniform. For example, non-corporate capital is mainly employed in the agricultural industries while government capital is concentrated in some of the services sector industries such as the rail transport industry. Equations (23.2)

state that the price index for capital type c is the weighted average of the rental value of the capital in all industries.

In GE-PAK there are five categories of land which are similar to that for capital discussed in the above paragraph. Hence, equations (23.3) which determine land price indices for five categories of land, are similar to the equations for capital price indices.

4.33 Market Clearing Equations for Primary Factors

Block 24 Market clearing equations for primary factors

$$\text{lambda}_{rp} = \frac{1}{\text{VYHOULAB}_{np}} \sum_{n \in \text{INC}} \text{VYHOULAB}_{mp} \times \text{ehoulab}_{mp} \quad r \in \text{REG}, p \in \text{PRF}, (24.1)$$

$$\begin{aligned} \text{x1cap}_{jc} = \frac{1}{\text{VICAP}_{jc}} & \left(\sum_{r \in \text{REG}} \sum_{n \in \text{INC}} \text{VYHOUCAP}_{mc} \times \text{ehoucap}_{mc} \right. \\ & + \sum_{o \in \text{COR}} \text{VYCORCAP}_{oc} \times \text{ecorcap}_{oc} \\ & + \text{YGOVCAP}_c \times \text{egovcap}_c \\ & \left. + \text{VYROWCAP}_c \times \text{erowcap}_c \right), \quad c \in \text{CAP}, (24.2) \end{aligned}$$

$$\begin{aligned} \text{x1lnd}_{jd} = \frac{1}{\text{V1LND}_{jd}} & \left(\sum_{r \in \text{REG}} \sum_{n \in \text{INC}} \text{VYHOULND}_{md} \times \text{ehoulnd}_{md} \right. \\ & + \sum_{o \in \text{COR}} \text{VYCORNLD}_{od} \times \text{ecorlnd}_{od} \\ & + \text{VYGOVLND}_d \times \text{egovlnd}_d \\ & \left. + \text{VYROWLND}_d \times \text{erowlnd}_d \right), \quad d \in \text{LND}. (24.3) \end{aligned}$$

Block 24 contains market clearing equations for the three primary factors: labour, capital, and land. For example, equation (24.1) states that the aggregate labour demand for profession p , from region r , is equal to the weighted sum of their supplies from households. The coefficients in the equations are computed from the income matrices given in Figure 4.27 and 4.28.

Equation (24.1) is derived from the following levels form:

$$PILAB_{rp} \times EHOULAB_{nrp} = \sum_{n \in INC} EHOULAB_{mp} \times PILAB_{rp},$$

$r \in REG, p \in PRF, (4.33.1)$

where (in levels) $EHOULAB_{mp}$ represents supply of labour type p from household type n in region r while $EHOULAB_{nrp}$ is the aggregate of these supplies over all 14 types of household. In the percentage-change form (see appendix B for the conversion rule) this is

$$p1lab_{rp} + ehoulab_{nrp} = \sum_n \left[\frac{EHOULAB_{mp} \times PILAB_{rp}}{PILAB_{rp} \times EHOULAB_{nrp}} (ehoulab_{mp} + p1lab_{rp}) \right],$$

$r \in REG, p \in PRF. (4.33.2)$

We cancel out $p1lab_{rp}$ from both sides to obtain the supply equation:

$$\lambda_{rp} = \frac{1}{VYHOULAB_{nrp}} \sum_n VYHOULAB_{mp} \times ehoulab_{mp},$$

$r \in REG, p \in PRF. (4.33.3)$

Equations (18.1) and (18.2), given in Block 18, compute total demands for labour by types from all industries. According to the market clearing assumption, we set total demand for labour by type, λ_{rp} , equal to their supplies defined in equation (4.33.3) to arrive at equation (24.1).

Similarly equations (24.2) and (24.3) define the market clearing conditions for capital and land. The coefficients in equations (24.2) and (24.3) are institutions' shares in total rental value of a factor type because the two factors are owned by all the institutions. Total earnings of all institutions from a factor is equal to the total rental value of that factor in all industries. Hence, the shares are computed over the total rental values of that factor in all industries.

4.34 Segmentation of Labour Market into Urban and Rural

The objective of this section is to discuss segmentation of the labour market into urban and rural, the functioning of these two markets, and their linkages. In GE-PAK the two labour markets are linked through a migration function. Block 32 contains a set of equations that defines rural-urban migration of labour. In this section we first discuss the main features of the

labour market in Pakistan, and determination of wage rates in rural- and urban-labour markets. We then describe a rural-urban migration function.

In the literature and statistics on labour force, the labour market in Pakistan is divided by two regions; urban and rural. The rural area represents all villages and small towns while the urban area comprises the big cities. According to GOP (1990), the market for rural labour accounted for 73 per cent of the total labour force in 1989-90. Some recent works on labour markets in Pakistan show that real wage rates in both markets are flexible and responsive to changes in labour supply and demand.

Chaudhry and Chaudhry (1992) have analysed trends in employment and real wage rates in Pakistan's rural-labour market for the period 1966 to 1985. According to them, the rural labour market is highly segmented and variations in employment and wage rates of labour occur in various segments. Villages, being physically separated, represent independent segments and each of them has its own distinct market conditions. Nevertheless, trends for average rural employment and wages in the rural labour market as a whole show that both employment and wages are determined by the free interplay of market forces. This empirical evidence on flexibility in wage rates in rural-labour markets in Pakistan is in line with that for other Asian countries. Binswanger and Rosenweig (1986), and Bardhan (1984) have shown that wage rates are flexible in rural Asia in the face of changes in relative scarcity, as are individual labour supplies and demands in the face of changes in wage rates. According to Bell (1991)⁴ such propositions about rural labour markets now command wide assent and form an important element in the "neo-classical resurgence" in development economics. As discussed by Bell (1991) two quite different interpretations may be made about this empirical evidence of wage and demand flexibility in rural labour markets. A group of

⁴Bell (1991) made a comprehensive review of recent work on the issues of markets, power and productivity in rural Asia.

development economists including Binswanger and Rosenweig asserts that the rural labour market is perfectly or nearly perfectly competitive, while Bardhan and some others assert that flexibility in wage rates and labour demand are compatible with various forms of imperfection in rural labour markets. Dreze and Mukherjee (1989) argue that though the "competitive" version is untenable as an exact description of how the labour market actually functions, it may nevertheless prove to be a good approximation. Considering the structure of rural activities in Pakistan, particularly agricultural production activities, we agree with the conclusion of Dreze and Mukherjee (1989). In the presence of various types of contract in agricultural activities such as tenancy, share-cropping and leasing of land in Pakistan, we consider that labour and other markets in rural areas are flexible in the sense that the terms of contracts respond to changes in scarcity. Hence, in our modelling of labour market and agricultural industries, we implicitly assume perfectly competitive markets. Further, as stated by Chaudhry and Chaudhry (1992), the consistent increases in real wages for rural workers suggest that Pakistan may no longer be considered a labour surplus economy. Khan and Lee (1984) found that real wages of agricultural workers in Pakistan witnessed continuous increases between 1960-61 and 1979-80; against the negligible increases in real wages in India, and falling real wages in Bangladesh during the same period. Chaudhry and Chaudhry (1992), and Bilquees (1992) also found consistent increases in real wages of agricultural workers in the 1980s. In this period, workers from middle-east begun returning and net-return migration became evident. In fact, some studies indicate that Pakistan's agriculture sector might be facing labour shortages, especially during the peak-demand period (Chaudhry, 1982; Guisinger, 1978).

For urban-labour markets, Guisinger (1978), Irfan (1982), and Irfan and Ahmad (1985) show that over the period 1970 to 1984, real wages of workers in the large-scale manufacturing and construction industries increased while that of government employees declined. Bilquees (1992) analysed this trend on an annual basis, and found that it continued in the late 1980s. Thus real

wages in Pakistan were found to be flexible even in the short run. Another issue related to the urban labour market is the role of trade unions in wage setting, or in the implementation of minimum wage rates set by the government. No recent evidence is found on the role of trade unions in wage setting in the manufacturing sector of Pakistan.⁵ A survey of trade unions in Asia (Far Eastern Economic Review, 1986) shows that trade union activity in Pakistan has been undermined by the 1977 martial law restrictions, and by factional and ideological divisions.

Considering this empirical evidence, we assume that wage rates in both urban and rural labour markets are flexible and responsive to changes in labour supply and demand. At the margin, the labour markets are cleared, within the given structure of the markets.

4.34.1 Rural-Urban Migration

Harris and Todaro (1970) developed an analytical model incorporating rural-urban migration to explain urban unemployment in the context of developing countries. Since then, various versions of their model have been developed.⁶ In all these models, the basic assumption is the rigidity of urban wages. Some models assume that urban wages are given exogenously while others assume a minimum urban wage rate. Either way, the difference in wage rates for urban and rural labour determines migration of labour between the two markets.

⁵ A study by Irfan (1982) found an interdependence between real wage gain and unionization in large-scale manufacturing industries during 1947-1969 period.

⁶ Some recent versions of Harris and Todaro model can be found in Chao and Yu (1992), Hazari and Sgro (1991), Margit (1991), Batra and Naqvi (1987), Beladi (1988), Beladi and Naqvi (1988), Khan and Naqvi (1983) *etc.*

Besides these analytical models, rural-urban migration has been incorporated in some applied general equilibrium models. In these models, real urban wages are assumed to be given exogenously.⁷

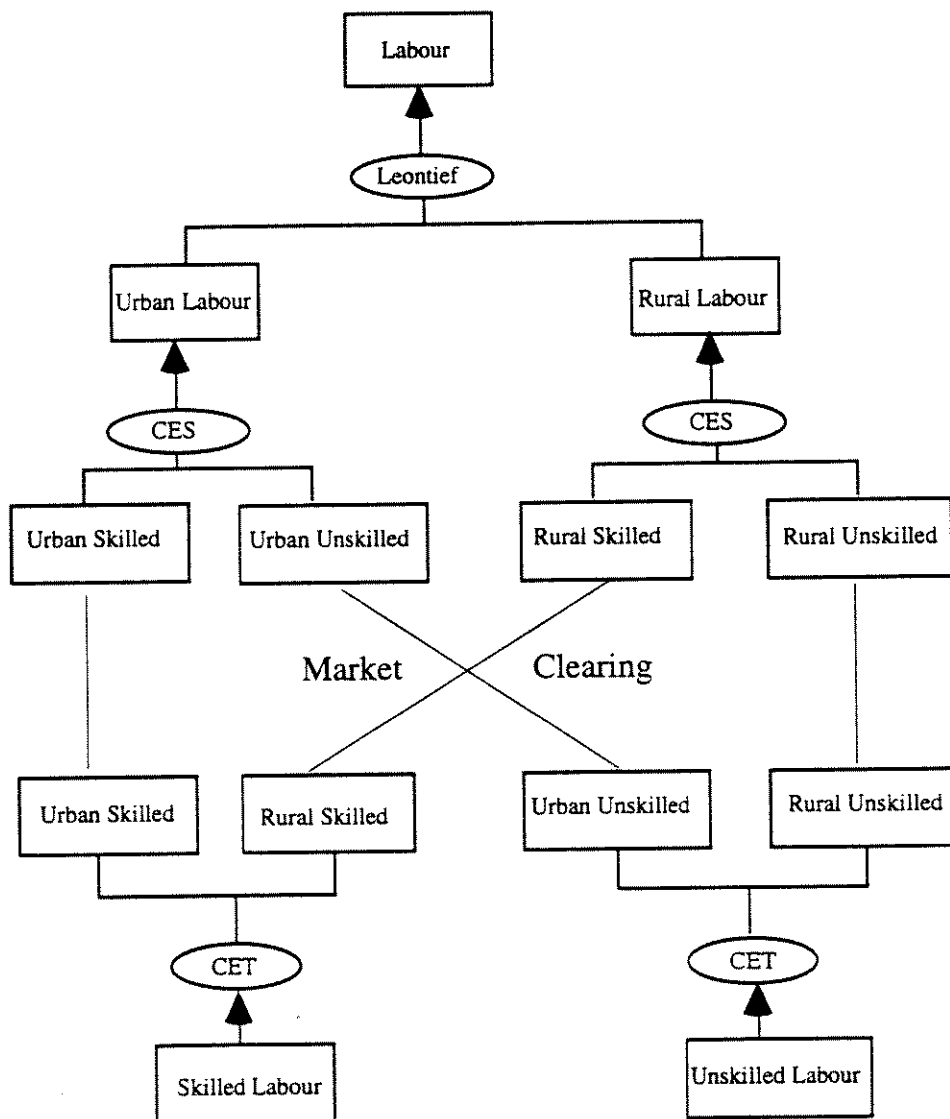
GE-PAK incorporates a set of equations that links the two rural and urban labour markets. Similar to the migration model of Harris and Todaro, or Blitzer, the difference in the wage rates in the two labour markets determines rural-urban migration. However, our migration function differs in three respects.

- (1) Wage rates in both urban and rural markets are determined endogenously.
- (2) Changes in relative real wages of urban and rural determine the number of households in the two regions. Since in our model labour is endowed by households which are categorised by region, migration of labour affects the number of households in each region. Hence rural-urban migration in our model occurs through migration of families.
- (3) In our model the labour market is divided by region and also by profession. In each region there are two types of profession; unskilled and skilled. The inter-region migration function is defined for two skill categories.

In the following paragraphs we discuss how the inter-region migration function, defined for households, determines labour supply in a region for a skill category.

⁷ With reference to energy-economy interaction models, Blitzer (1986) in the applied general equilibrium model for developing countries has defined two sectors, urban and rural; and two types of labour. Changes in the rural and urban labour forces depend on population growth rate in the two sectors and the rate of rural-urban migration. The latter is a positive function of the ratio of expected urban labour income to the average rural labour income.

Figure 4.29 Labour Demand and Supply Structure



4.34.2 Rural-Urban Migration by Household Types, and Real Wages

As discussed in Section 4.26, industries in each region demand two types of labour. Labour costs are minimised through substitution between skilled and unskilled labour, given their wages rates in that region (see the top of Figure 4.29). The changes in supply of a profession type in a region is determined by inter-region migration of labour in that category. The bottom of Figure 4.29 shows this structure of labour supply. At the bottom level we assume that labour supply by profession is fixed, however, the inter-region distribution of a profession is determined by a CET function.

Block 25 covers the equations determining this labour supply function through the inter-region migration of households (which possess labour). Our basic assumption is that

$$\left(\frac{Q(\text{"urban"}, np)}{Q(\text{"rural"}, np)}\right) = f\left(\frac{P1LABR\_j(\text{"urban"}, np)}{P1LABR\_j(\text{"rural"}, np)}\right), \quad n \in INC, p \in PRF, (4.34.1)$$

where Q is the number of households, by region and profession, of a household type, and $P1LABR\_j$ are the real wages for these households

Hence changes in real wages of urban labour relative to rural labour for profession p will change the ratio of urban households to rural households within each group of households. Equation 25.1 in Block 25 states this behavioural assumption in percentage change form for a CET functional form.

Block 25 Rural-Urban migration and real wages

$$q_{rnp} = q_{rnp} + \sigma REG_p \times (p1labr\_j_{mp} - p1labr\_j_{np}), \quad r \in REG, n \in INC, p \in PRF, (25.1)$$

$$p1labr\_j_{np} = \frac{1}{VYHOULAB\_rnp} \sum_{r \in REG} VYHOULAB_{mp} \times p1labr\_j_{mp}, \quad n \in INC, p \in PRF, (25.2)$$

$$q_{p_m} = \frac{1}{ADJ_p \times VYHOULAB\_p_m} \sum_{p \in PRF} (VYHOULAB_{mp} \times ADJ_p) \times q_{mp}, \quad r \in REG, n \in INC, (25.3)$$

$$p1labr\_j_{mp} = p1lab\_j_{rp} + xiitem_m, \quad r \in REG, n \in INC, p \in PRF, (25.4)$$

$$p1lab_{rpj} = xi3 + flwag\_j_{rp}, \quad r \in REG, p \in PRF, j \in IND. (25.5)$$

As discussed in Section 4.4, there are 14 groups of households in the model; categorised by region (urban, rural), and 7 types of groups (subscripted by n). Our assumption is that the number of households by profession and type, q_{rnp} , is given exogenously. A change in the real wage rate ($p1labr\_j_{rp}$), for a profession p in region r , relative to an average wage rate ($p1labr\_j_{np}$), determines the number of households of type n , possessing labour type p , in region r . For example, an increase in the real wage of urban-skilled labour relative to the average increase in wage rate for skilled labour will increase the

number of urban-skilled households in that group of households. The average wage rate is the weighted-average of real wages in the two regions for a profession. The parameter, σ_{REG_p} , is the elasticity of inter-region migration for profession p ; it measures the responsiveness of migration of households to changes in the relative real wage rates in the two regions.

Equation (25.1) states that households in each group make migration decisions on real wages received by them. Therefore in equation (25.4), we have defined real wages for each income group, $plabr_{jrp}$, separately. We deflate industry-aggregated wages of each profession in a region ($plab_{jrp}$) by the price indices for groups of households ($xiitem_m$). The variables $plabr_{rjnp}$ represent the average real wages for household type n with profession p . Equation (25.2) computes these average wage rates. The weights in equation (25.2) are shares of wage-earnings of household type n , from region r , in the total wage bill of profession p , in the two regions of that household type. Equation (25.3) aggregates households by profession, because the income and expenditure accounts of households are not given separately by profession type. We use shares of households' labour income by profession as the weights to aggregate the households by profession. Our data base does not contain the number of households by profession, therefore, we adjust the labour income to take into account the differences between wages of skilled and unskilled labour in the base year.

Equations (25.5) define real wages, in industries, for labour by region and profession. The variables $flwag_{jrp}$ represent shift in real wages by region and profession. In a closure, when changes in labour supply by profession and region ($ulab_{jrp}$) are given exogenously, these shift variables are determined endogenously and represent changes in real wages which clear the labour market.

4.35 Endowments of Primary Factors by Institution

The equations in Block 26 set default rules to determine the supply of primary factors from the 4 types of institution. Equation (26.1) states that the

labour supply of profession p , from the household type n in region r , is determined by the number of households, and the shifts in their labour supplies. The variable $ulab_{rp}$ indicates a shift in labour supply of profession p in region r which are assumed to occur in all types of households uniformly. For example, if there is an increase in urban-skilled labours then supply of urban-skilled labours increase in all income groups uniformly. The number of households of type np in a region is determined by the inter-region migration function discussed in Section 4.34.

Block 26 Equations determining factor endowments by institution

$$ehoulab_{mp} = ulab_{jp} + q_{mp}, \quad r \in REG, n \in INC, p \in PRF, (26.1)$$

$$ehoucap_{mc} = ucap_{jc} + q_{pm}, \quad r \in REG, n \in INC, c \in CAP, (26.2)$$

$$ehoulnd_{md} = ulnd_{jd} + q_{pm}, \quad r \in REG, n \in INC, d \in LND, (26.3)$$

$$ecorcap_{oc} = ucap_{jc}, \quad o \in COR, c \in CAP, (26.4)$$

$$ecorlnd_{od} = ulnd_{jd}, \quad o \in COR, d \in LND, (26.5)$$

$$egovcap_c = ucap_{jc}, \quad c \in CAP, (26.6)$$

$$egovlnd_d = ulnd_{jd}, \quad d \in LND, (26.7)$$

$$erowcap_c = ucap_{jc}, \quad c \in CAP, (26.8)$$

$$erowlnd_d = ulnd_{jd}, \quad d \in LND. (26.9)$$

As discussed in Section 4.3, the linearised approach has the flexibility of grouping the variables into exogenous and endogenous categories. Hence, a variable can either be assumed exogenous or it can be determined endogenously by the model. In a scenario assuming an elastic supply of labour, the shift-variables of labour supply by type are determined endogenously against fixed wage rates of the corresponding labour type. Alternatively, we can exogenously set the shift variables of labour supply for each skill category. In the latter case the corresponding wage-shift variables are determined endogenously (see Block 25 in Section 4.34 for wage-shift equation).

4.36 Income of Institutions by Source

Block 27 Equations determining institutions' income by source

$$yhoulab_{rp} = ehoulab_{rp} + pllab_{jr}, \quad r \in REG, n \in INC, p \in PRF, (27.1)$$

$$yhoucap_{mc} = ehoucap_{mc} + plcap_{jc}, \quad r \in REG, n \in INC, c \in CAP, (27.2)$$

$$yhouInd_{md} = ehoulnd_{md} + plnd_{jd}, \quad r \in REG, n \in INC, d \in LND, (27.3)$$

$$ycorcap_{oc} = ecorcap_{oc} + plcap_{jc}, \quad o \in COR, c \in CAP, (27.4)$$

$$ycorInd_{od} = ecorInd_{od} + plnd_{jd}, \quad o \in COR, d \in LND, (27.5)$$

$$ygovcap_c = egovcap_c + plcap_{jc}, \quad c \in CAP, (27.6)$$

$$ygovInd_d = egovInd_d + plnd_{jd}, \quad d \in LND, (27.7)$$

$$yrowcap_c = erowcap_c + plcap_{jc}, \quad c \in CAP, (27.8)$$

$$yrowInd_d = erowInd_d + plnd_{jd}, \quad d \in LND, (27.9)$$

$$yhouhou_{muv} = fyhouhou_{muv} + yhh, \quad r \in REG, n \in INC, u \in REG, v \in INC, (27.10)$$

$$yhoucor_{mo} = drate_o + ycor_o, \quad r \in REG, n \in INC, o \in COR, (27.11)$$

$$yhougov_m = fyhougov_m + ygov, \quad r \in REG, n \in INC, (27.12)$$

$$yhourow_m = fyhourow_m + phi, \quad r \in REG, n \in INC, (27.13)$$

$$ygovhou_m = yhou_m + tyhou_n, \quad r \in REG, n \in INC, (27.14)$$

$$ygovcor_o = ycor_o + tycor_o, \quad o \in COR. (27.15)$$

Block 27 covers equations determining the income, by source, of all the four institutions. The institutions' incomes from rewards on primary factors are determined by their supply of primary factors and the corresponding price indices of these factors. In the levels form, an institutions' income from a source—say private corporation's income from capital—is defined as

$$YCORCAP_c = E0CORCAP_c \times P1CAP_{jc},$$

$$o = \text{private corporations}, c \in CAP, (4.36.1)$$

where $YCORCAP_c$ represents private corporations' income from capital type c , which is determined by the supply of capital type c , $E0CORCAP_c$, from the

private corporations, and the price index of capital type c , $P1CAP_{jc}$. In the percentage-change form (see appendix B for the conversion rules) this is

$$ycorcap_c = ecorcap_c + p1cap_{jc}, \quad c \in CAP. \quad (27.4)$$

The above procedure is applied to arrive at equations (27.1) to (27.9) which calculate institutions' income from primary factors.

In Block 27, equations (27.10) to (27.15) set the default rules to determine the households' income from payments received from:

- other households;
- corporations;
- government; and
- ROW.

In each case the payments received by households are in proportion to the incomes of the institutions which make the payments and the shift variables that allow us to exogenously change the average rate of transfer in each case. For example, in equation (27.11) the income of household type m from private corporations is determined by the private corporations' income, $yprc_o$, and their average dividend rate, $drate_o$. In the absence of any change in the base-year dividend rate, household income from private corporations is defined in proportion to the income of private corporations.

It is noteworthy that for households, the rate of transfer payments from other households ($fyhouhou_{mu\nu}$), from the government ($fyhougov_m$), and from ROW ($fyhourow_m$) are specific to the household type while the dividend rate from the two types of corporation, $drate_o$, are uniform for all 14 types of household.

Though equations (27.10) to (27.13) are computed for all the 14 types of household, not all of them receive the 4 types of transfer payment. The shares of these transfer payments are zero in the incomes of some of the groups, in the base year. Hence the changes in transfer payments computed in these equations are not accounted for in the aggregation of the households' incomes.

Equations (27.14) to (27.15) compute total transfer payments received by the government from households and from the two types of corporation. These transfer payments are in direct proportion to incomes of households and corporations, and the shift variables that represent the changes in the average rates of transfer payments.

4.37 Incomes of Institutions

Block 28 Equations determining institution's income

$$\begin{aligned}
 y_{hou_m} = \frac{1}{VYHOU_m} \bigg(& \sum_{p \in PRF} VYHOULAB_{mp} \times y_{houlab_{mp}} \\
 & + \sum_{c \in CAP} VYHOUCAP_{mc} \times y_{houcap_{mc}} \\
 & + \sum_{d \in LND} VYHOULND_{md} \times y_{houlnd_{md}} \\
 & + \sum_{o \in COR} VYHOU COR_{mo} \times y_{houcor_{mo}} \\
 & + \sum_{u \in REG} \sum_{v \in P INC} VYHOUHOU_{muv} \times y_{houhou_{muv}} \\
 & + YHOUGOV_m \times y_{hougov_m} \\
 & + VYHOUROW_m \times y_{hourow_m} \bigg), \quad r \in REG, n \in INC, (28.1)
 \end{aligned}$$

$$\begin{aligned}
 y_{cor_o} = \frac{1}{VYCOR_o} \bigg(& \sum_{c \in CAP} VYCORCAP_{oc} \times y_{corcap_{oc}} \\
 & + \sum_{d \in LND} VYCORLND_{od} \times y_{corlnd_{od}} \bigg), \quad o \in COR, (28.2)
 \end{aligned}$$

$$\begin{aligned}
 y_{gov} = \frac{1}{VYGOV} \bigg(& \sum_{c \in CAP} VYGOVCAP_c \times y_{govcap_c} \\
 & + \sum_{d \in LND} VYGOVLND_d \times y_{govlnd_d} \\
 & + \sum_{o \in COR} VYGOVCOR_o \times y_{govcor_o} \\
 & + \sum_{r \in REG} \sum_{n \in INC} VYGOVHOU_m \times y_{govhou_m} \\
 & + VYGOVTAX \times t0rev + V1OCT_j \times octrev \bigg). \quad (28.3)
 \end{aligned}$$

Equations covered in Block 28 add up institutions' income by sources. The aggregate income of an institution is the weighted sum of its income from

various sources. For example the aggregate income of private corporations is the weighted sum of its income from rental value of capital and land. The coefficients in these equations are the shares of income from various sources in total income of an institution. These coefficients are computed within the equations, using the matrices from the income mapping data base given in Figures 4.27 and 4.28 (in Section 4.31).

It is noteworthy that in aggregating the total income of government we have included income from indirect tax revenues. The equations determining indirect tax revenue is discussed in Section 4.28.

4.38 Aggregate Expenditure and Disposable Income of Households by Household Types

Block 29 Equations of household expenditure and disposable income

$$y_{hou\bar{d}m} = \frac{1}{VYHOUD_m} \left(VYHOU_m \times y_{houm} - VYGOVHOU_m \times y_{govhoum}, \right. \\ \left. - \sum_{u \in REG} \sum_{v \in INC} VYHOUHOU_{muv} \times y_{houmuv} \right), \\ r \in REG, n \in INC, (29.1)$$

$$y_{hou\bar{d}r_m} = y_{hou\bar{d}m} - xiitem_m, \quad r \in REG, n \in INC, (29.2)$$

$$chou_m = y_{hou\bar{d}m} + apc_m, \quad r \in REG, n \in INC. (29.3)$$

Block 29 contains equations determining households' nominal and real disposable income. In the levels form, disposable income of household type rn is defined as the household's income net of payments made to the government and to other households. Equation (29.1) gives this default rule in the linear form (for the conversion rules see Appendix B). The data matrix, $YHOUD_m$, is the disposable income of each household type computed from the data base. In equation (29.1) the coefficients are the shares of transfer payments made by the household type rn and the share of its total income in the disposable income. The real disposable income of households by type is obtained by deflating the disposable income of household type rn by its CPI (see Section 4.30 for computation of consumer price indices for 14 types of household). Equations (29.3) determine household expenditures by household types. It is

assumed that the nominal expenditure of household type m is a function of its disposable income. The variable apc_m represents the average propensity to consume for the household type m .

4.39 GNP and the Balance of Payments

GE-PAK defines incomes and savings for the domestic institutions. To incorporate a consistency check on national income and expenditures we have defined equations determining GNP measured by income and expenditure.

Equation (30.1) states that the gross national expenditure of the economy is the weighted sum of current expenditure of private and the public sector plus the domestic savings. In equation (30.1) the coefficients are the shares of these three components in GNP. Equation (30.2) defines aggregate domestic savings as the weighted sum of savings of households, private corporations, public corporations and the government.

Block 30 Equations for GNP and Balance of payments

$$gnpexp = \frac{1}{GNPEXP} (VITEM\_km \times chou\_m + PUR5\_is \times oth + VSAV \times sav), \quad (30.1)$$

$$sav = \frac{1}{VSAV} \left(\sum_{o \in COR} VSAVCOR_o \times savcor_o + VSAVGOV \times savgov + \sum_{r \in REG} \sum_{n \in INC} VSAVHOU_m \times savhou_m \right), \quad (30.2)$$

$$gnpinc = \frac{1}{GNPINC} (GDPIN \times gdpinc + VNFI \times nfi), \quad (30.3)$$

$$nfi = \frac{1}{VNFI} \left(\sum_{r \in REG} \sum_{n \in INC} VYHOUROW_m \times yhourow_m - \sum_{c \in CAP} VYROWCAP_c \times yrowcap_c - \sum_{d \in LND} VYROWLND_d \times yrowlnd_d \right), \quad (30.4)$$

$$1000 \times 100 \times delLON = PUR2\_isj \times inv - VSAV \times sav. \quad (30.5)$$

In equation (30.3) we define the gross national income as the weighted sum of GDP and net factor income from abroad. The net factor income from abroad is the difference between the income received by Pakistan for selling

its factors' services to the rest of the world, and the payments made by Pakistan for employing foreign-owned factors. Equation (30.4) defines this relationship. The coefficient VNFI is the base year value of net factor income from abroad. In the data base, the factor income from abroad is the remittances received by households from ROW, while the factor payments to ROW are the rental accruing to foreigners on their portion of fixed capital stock (capital and land).

Equation (30.5) computes the ordinary change in the transfer of resources from the rest of the world to Pakistan; this is defined as the difference between the national savings and investment.

4.40 Savings of Domestic Institutions

Block 31 Equations of domestic savings by institutions

$$y_{\text{houd}_m} = \frac{1}{V_{\text{HOUD}_m}} (V_{\text{SAVHOU}_m} \times \text{savhou}_m + V_{\text{ITEM}_k}_m \times \text{chou}_m),$$

$r \in \text{REG}, n \in \text{INC}, (31.1)$

$$y_{\text{gov}} = \frac{1}{V_{\text{YGOV}}} (V_{\text{SAVGOV}} \times \text{savgov} + \text{PUR5\_is} \times \text{oth} + V_{\text{YHOUGOV}_m} \times \text{yhougov}_m),$$

(31.2)

$$y_{\text{cor}_o} = \frac{1}{V_{\text{YCOR}_o}} (V_{\text{SAVCOR}_o} \times \text{savcor}_o + V_{\text{YGOVCOR}_o} \times \text{ygovcor}_o + \sum_{r \in \text{REG}} \sum_{n \in \text{INC}} \text{SYHOUCOR}_{\text{mo}} \times \text{yhoucor}_{\text{mo}}),$$

$o \in \text{COR}. (31.3)$

Equations (31.1) to (31.3) compute savings of the domestic institutions. The savings of each institution (in the levels form) is defined as the difference between its income and its expenditure. For households, their savings are computed from their disposable incomes. Equation (31.2) defines government savings. The government's expenditure consists of its current expenditure and the transfer payments made by it. Again, the coefficients are the shares of savings and expenditure in the government's income. For the two types of corporation, expenditure is measured by the sum of dividends and corporate taxes paid.

4.41 Closing the Model

Table 4.5 gives the number of equations and variables defined for each set. Column 1 gives the total number of variables which have same dimensions, and column 2 gives the number of equations defined on these dimensions. In our model, total number of variables (m) are greater than number equations (n). The third column gives the number of unexplained variables ($m-n$). To close the model, we make ($m-n$) variables exogenous to the model. The last column in Table 4.5 contains our selected exogenous variables. This selection represents one plausible closure of the model which is suitable for short-run simulation. One can select another set of exogenous variables, as the model allows us to swap exogenous variables with endogenous variables, but the total number of exogenous variables should remain the same.

We have used the closure given in Table 4.5 for the simulation results reported in Chapter 6. Section 6.2 explains this closure in detail. As discussed by Dixon *et al.* (1982, p.148), no theory can be made to define a closure. Nevertheless, two general rules should be observed. Firstly, if the quantity of a factor or commodity is given exogenously then its price is determined endogenously. If both the quantity and the price variables are given exogenously then a slack variable should be determined endogenously to meet the market clearing conditions. In GE-PAK, there are various shift variables that may be used as slack variables. Secondly, because the model determines prices only in relative terms at least one monetary variable should be included in the exogenous list to determine the absolute price level.

Table 4.5 Tally of Variables and Equations for a Short-run Closure

Set Name	Variable Count (1)	Equation Count (2)	Exogenous Count (3)	Unexplained Variables (4)
Macros	52	44	8	f5tot, phi, t0, t1_isj, t2_isj, t3_is, t5_is, rtot.
ADM $\times$ SRC	1	1	0	
CAP	7	7	0	
CAP $\times$ IND	2	2	0	
COM	12	6	6	fep _i , feq _i , pmi _i , t4 _i , tm _{ii} , t3_e _i .
COM $\times$ IND	8	4	4	a1_sij, a2_sij, t1_eij, t2_eij.
COM $\times$ MAR	2	1	1	a4mar _{im} .
COM $\times$ SRC	9	7	2	f5 _{is} , t _{is} .
COM $\times$ SRC $\times$ IND	8	6	2	a1_isj, a2_isj.
COM $\times$ SRC $\times$ IND $\times$ MAR	4	2	2	a1mar _{isjm} , a2mar _{isjm} .
COM $\times$ SRC $\times$ MAR	4	2	2	a3mar _{ism} , a5mar _{ism} .
COR	5	3	2	tycor _o , drate _o .
COR $\times$ CAP	2	2	0	
COR $\times$ LND	2	2	0	
IND	27	16	11	atot _j , alcap_cj, allab_rpj, alld_dj, aloctj, a2_isj, floctj, alprm _j , xlld_dj, xlcap_cj, yj.
INC $\times$ PRF	2	1	1	q_rnp.
ITM	2	2	0	
ITM $\times$ COM $\times$ SRC	1	1	0	
ITM $\times$ COM	2	2	0	
ITM $\times$ REG $\times$ INC	4	3	1	aitem _{km} .

..... continued

Table 4.5 (continued)

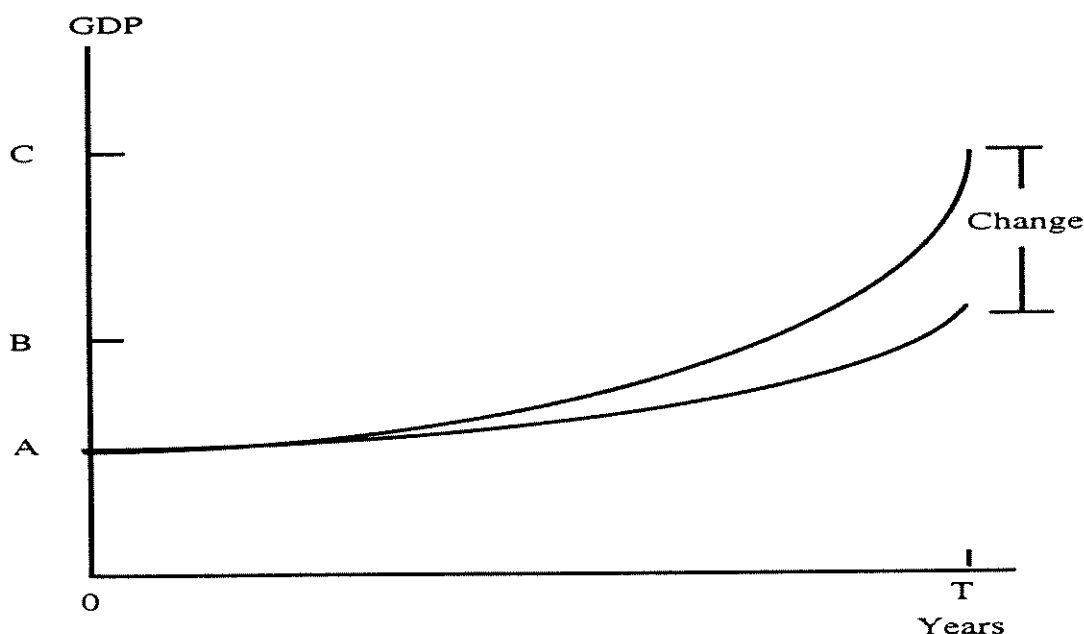
Dimension	Variable Count	Equation Count	Exogenous Count	Unexplained Variables
LND	7	7	0	fyhou_gov _m , fyhou_row _m , thou _m , apc _m , hsize _m .
LND × IND	2	2	0	
PRF	1	1	0	
REG	1	1	0	
REG × INC	19	14	5	
REG × INC × CAP	2	2	0	
REG × INC × COR	1	1	0	
REG × INC × PRF	4	4	0	
REG × INC × LND	2	2	0	allab _{rpj} .
REG × IND	2	1	1	
REG × PRF	4	3	1	
REG × PRF × IND	3	2	1	
REG × INC × REG × INC	2	1	1	fyhouhou _{mm} .

4.42 A Comparative-Static Interpretation of the Model's Results

GE-PAK is designed for comparative-static simulations. Its equations and variables all refer implicitly to the economy at some future time-period.

This interpretation is illustrated by Figure 4.30 which graphs the value of some variable, say GDP, against time. A is the level of GDP in the base year and B is the level which it would attain in T years time if some policy change say—a tariff change—were not implemented. With the tariff change, GDP would reach C, all other things being equal.

Figure 4.30 Comparative-Static Interpretation of Results



The model generates the percentage change in GDP, $100(C-B)/B$, showing how GDP in period T would be affected by the tariff change alone. The model can be used to carry out comparative static simulations of short-run or long-run effects of a policy change. For short-run simulations, capital stocks are held at their pre-shock levels. This implies that the short-run period is long enough for the prices and quantities of all commodities and factors to adjust to the given shock, but sufficiently short that we can ignore changes in industry capital stock available for use in production. This period could be two years, *i.e.*, $T = 2$.

In long-run simulations, it is assumed that capital stocks will have adjusted to restore (exogenous) rates of return—this might take 10 or 20 years. In either case the choice of closure and the interpretation of results depend on the timing of changes: the model itself is atemporal. Consequently it tells us nothing of adjustment paths (the shape of curves between 0 and T in Figure 30).

4.43 The Percentage Change Approach to Solve the Model

Following Johansen (1960) and Dixon *et al.* (1982), GE-PAK is solved as series of linear equations relating percentage changes in the model's variables. In this section we first explain how the linearised form can be used to generate exact solutions of the underlying non-linear equations, as well as to compute linear approximations to those solutions. This section is based on the explanation for solving ORANI-F contained in Horridge *et al.*, (1992). Subsection 4.43.1 explains the role of the initial solution in solving the model by this method.

A typical AGE model can be represented in the levels as:

$$F(Y,X) = 0 \quad (4.43.1)$$

where Y is a vector of endogenous variables, X is a vector of exogenous variables, and F is a system of non-linear functions. The problem is to compute Y , given X . Normally we can not write Y as an explicit function of X .

Several techniques have been devised for computing Y . The linearised approach starts by assuming that we already possess some solution to the system, $\{Y^0, X^0\}$ *i.e.*,

$$F(Y^0, X^0) = 0 \quad (4.43.2)$$

Normally the initial solution $\{Y^0, X^0\}$ is drawn from historical data: we assume that our system of equations was true for some point in the past. With conventional assumptions about the form of the F function it will be true that for small changes; dy and dx ,

$$F_Y(Y,X)dY + F_X(Y,X) dX = 0, \quad (4.43.3)$$

where F_Y and F_X are matrices of the derivatives of F with respect to Y and X , evaluated at $\{Y^0, X^0\}$. For reasons explained below, we find it more convenient to express dy and dx as small percentage changes, *i.e.*, y and x . Thus y and x are some typical elements of Y and X vectors, and are given by:

$$y = 100dY/Y, \text{ and } x = 100dX/X. \quad (4.43.4)$$

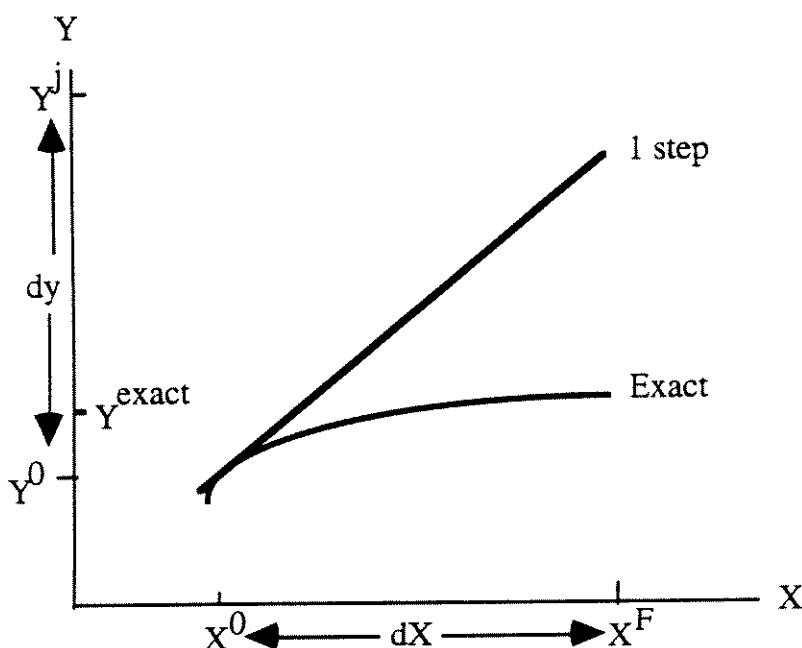
Correspondingly we define:

$$G_Y(Y, X) = F_Y(Y, X)\hat{Y} \text{ and } G_X(Y, X) = F_X(Y, X)\hat{X}, \quad (4.43.5)$$

where $\hat{Y}$ and $\hat{X}$ are diagonal matrices. Hence the linearised system becomes:

$$G_Y(Y, X)y + G_X(Y, X)x = 0 \quad (4.43.6)$$

Figure 4.31 Linearisation Error



Such systems are easy for computers to solve, using standard techniques of linear algebra. But they are accurate only for small changes in Y and X . Otherwise, linearisation error may occur. The error is illustrated by Figure 4.31 which shows how some endogenous variable Y changes as an exogenous variable X moves from X^0 to X^F . The true, non-linear relation between X and Y

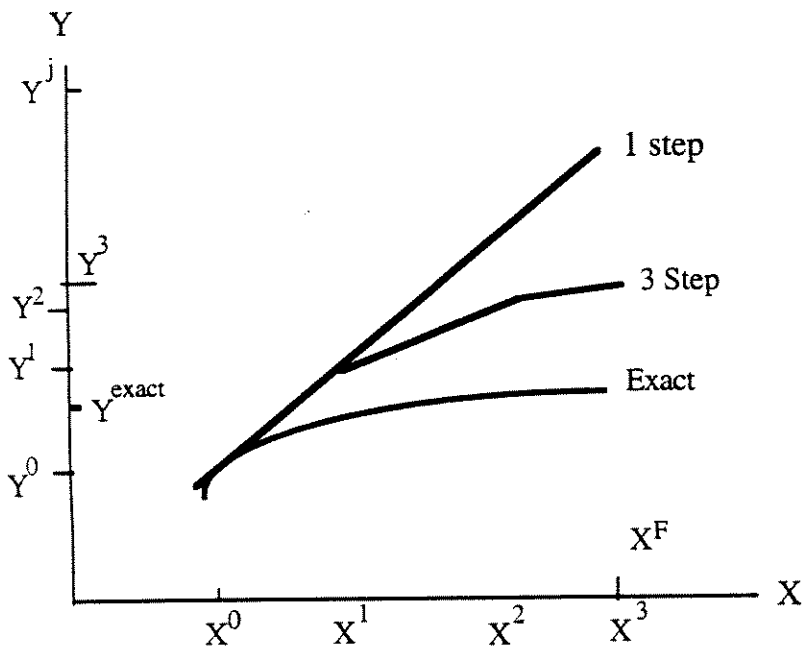
is shown as a curve labelled as "exact". The linear, or first-order, approximation:

$$y = - G_Y(Y,X)^{-1} G_X(Y,X)x \tag{4.43.7}$$

leads to the Johansen estimate Y^J —an approximation to the true answer, Y^{exact} .

Figure 4.31 suggests that, the larger is x , the greater is the proportional error in y . This observation leads to the idea of breaking large changes in X into a number of steps, as shown in Figure 4.32. For each sub-change in X , we use the linear approximation to derive the consequent sub-change in Y . Then using the new values of X and Y , we recompute the coefficient matrices G_Y and G_X . The process is repeated for each step. If we use 3 steps (see Figure 4.32), Y^3 , *i.e.* the final value of Y , is closer to Y^{exact} than was the Johansen estimate Y^J . We can show, in fact, that given sensible restrictions on the derivatives of $F(Y, X)$, we can obtain a solution as accurate as we like by dividing the process into a sufficient number of steps.

Figure 4.32 Multi-step Process to Reduce Linearisation Error



The technique illustrated in Figure 4.32, known as the Euler method, is the simplest of several related techniques of numerical integration—the

process of using differential equations (change formulae) to move from one solution to another. GEMPACK, the computer software used to solve the model, offers the choice of several such techniques. Each requires the user to supply an initial solution (Y^0, X^0); formulae for the derivative matrices G_Y and G_X , and the total percentage change in the exogenous variables, x . The levels functional form, $F(Y, X)$, need not be specified, although it underlies G_Y and G_X .

The accuracy of multi-step solution techniques can be improved by extrapolation. Suppose the same experiment was repeated using 4-step, 8-step and 16-step Euler computations, yielding the following estimates for the total percentage change in some endogenous variable Y :

$$y(4\text{-step}) = 4.5\%,$$

$$y(8\text{-step}) = 4.3\% \text{ (0.2\% less), and}$$

$$y(16\text{-step}) = 4.2\% \text{ (0.1 \% less).}$$

Extrapolation suggests that the 32-step solution would be:

$$y(32\text{-step}) = 4.15 \% \text{ (0.05 \% less),}$$

and that the exact solution would be:

$y(\infty\text{-step}) = 4.1\%$. The extrapolated result requires 28 ($= 4 + 8 + 16$) steps to compute but would normally be more accurate than the results given by a single 28-step computation. Alternatively, extrapolation enables us to obtain given accuracy with fewer steps. As we noted above, each step of a multi-step solution requires: computation of the percentage-change derivative matrices G_Y and G_X from historical data; solution of the linear system (4.43.6); and the use of that solution to update the data (Y, X). In our model we have defined a set of data coefficients V , which is a function of X and Y , *i.e.*, $V = H(X, Y)$. Most elements of V are simple costs or expenditure flows from the input-output table. G_Y and G_X turn out to be simple functions of V , often indeed identical to elements of V . After each small change, V is updated using the formula $v = H_Y(X, Y)y + H_X(X, Y)x$. Hence the basic flows in the base year

are updated for every small change. The updated data base contains the basic flows for the shock in the next step.

4.43.1 The Role of the Initial Solution and its Appropriate Explanation

In our explanation of the model's simulation results in percentage change form, it is assumed that we possess an initial solution of the model— $\{Y^0, X^0\}$ or the equivalent V^0 —and that results are deviations from this initial state. However, this assumption raises one difficulty. Our data base does not, like B in Figure 4.30, show the expected state of the economy at a future date. Instead the most recently available historical data, represented by A in Figure 4.30, is used. In our study this point is represented by 1983-84 data. At best this data base refers to the present-day economy. Note that for an atemporal static model, 'A' provides a solution to the model for period T. In the static model, setting all exogenous variables at their base-period levels would leave all the endogenous variables at their base-period level. Nevertheless, 'A' may not be an empirically plausible control state for the economy at period T, and the question therefore arises: do estimates of the percentage-change effects of B-to-C of a cut in the import tax in 1988 differ much from the cut in 1993? Probably not. Firstly, a balanced growth, or a proportional enlargement of the model data base, just scales equation coefficients equally: it does not affect our results. Second, compositional changes, which do alter percentage-change effects, happen quite slowly. So for short- and medium-run simulations, 'A' is a reasonable proxy for B.

4.44 Computational Aspects of the model

We have used GEMPACK for the computer implementation of our model. It is a suite of general-purpose economic modelling software especially suitable for general and partial equilibrium models. It has been developed to automate the solution of large economic models by Johansen's method. It can handle a wide range of economic behaviour and contains capabilities for solving inter-temporal models. The objective of this section is to briefly

introduce GEMPACK and its solution strategy. We also describe the steps involved to implement a model using it. First, we discuss the solution strategy of GEMPACK and then outline the procedure to implement GE-PAK using GEMPACK (see *GPD-1* to *GPD-4* (IMPACT Project, 1993) for further details on the implementation).

4.44.1 The Solution Strategy

In GEMPACK, Johansen solutions are calculated by solving the linearised equations of the model. As discussed in Section 4.43, a typical AGE model can be represented by a system of linear equations:

$$F(Y, X) = 0, \quad (4.44.1)$$

and the solution to this equation system is

$$y = - G_Y(Y, X)^{-1} G_X(Y, X)x, \quad (4.44.2)$$

or alternatively

$$y = - A_Y^{-1} A_X x, \quad (4.44.3)$$

where A_Y is the matrix of coefficients of endogenous variables and A_X is the vector of coefficients of exogenous variables. The vectors y and x contain endogenous and exogenous variables respectively. If there are n equations in a model containing m variables (m should always be greater than n) then to solve the system of equations, the number of endogenously determined variables should be equal to the number of equations. Out of the total m variables, $(m-n)$ variables should be exogenous. Thus the matrix A_Y is a square matrix of $n \times n$ and the matrix A_X is of dimension $n \times (m-n)$. The solution vector (y) is of dimension $n \times 1$ and the vector of exogenous variables has dimension of $(m-n) \times 1$. One way of solving (4.44.3) is the traditional matrix inversion method. However, this approach uses significant computer processing time for big models when the size of matrix A_Y is large. To solve the linear equation

system (4.44.3) GEMPACK uses an 'LU method'⁸. In this method, a "*Doolittle decomposition*" or "*Crout decomposition*" is performed on the matrix A_Y and the equation system is solved in two steps. The following paragraphs describe the application of the 'LU method' to solve the linear equation system (4.44.3).

We can re-write equation (4.44.3) as follows:

$$A_Y y = -A_X x, \quad (4.44.4)$$

where the vector of endogenous variables y and the vector of exogenous variables x are defined as percentage change variables. Therefore, from the above equation it follows that the matrix of elasticities (E) of the model satisfies:

$$A_Y E = -A_X, \quad (4.44.5)$$

where $E = -[A_Y^{-1} A_X]$. The ij th element of E is the elasticity of the i th endogenous variable with respect to the j th exogenous variable. Thus having computed E , the solution for y in (4.44.3) for a given set of exogenous shocks to x is generated from:

$$y = E x. \quad (4.44.6)$$

To compute the elasticity matrix E , the LU decomposition algorithm factors the square matrix A_Y as:

$$A_Y = LU, \quad (4.44.7)$$

where L is a lower triangular matrix and U is an upper triangular matrix. Following this, we first solve the problem:

$$L Z = A_X, \quad (4.44.8)$$

where Z is a vector containing intermediary values. Second, with Z computed, we solve:

$$U E = Z. \quad (4.44.9)$$

⁸ Pearson and Rimmer (1983) discussed this more efficient alternative technique of 'LU methods' which was first suggested by Duff (1977, 1981).

Equations in (4.44.8) and (4.44.9) can be solved directly. By performing 'forward substitution' in (4.44.8) and 'backward substitution' in (4.44.9), there is only one unknown variable in each equation. Although for given A_Y the LU method is scarcely more efficient than simpler methods such as Gaussian elimination, it facilitates the re-computation of y for a new shock vector x . If the coefficient matrices A_Y and A_x are unchanged, the same LU decomposition may be used to compute the effects of a series of shocks.

4.44.2 The Steps to Implement the Model on Computer using GEMPACK

GEMPACK provides a computer-assisted method of converting an algebraic representation of the equations of a GE model into a tailor-made computer program which produces accurate solutions of the model. The programs included in GEMPACK are as follows.

- (1) For implementing and carrying out simulations:

TABLO	for processing the description of the model
SAGEM	for carrying out Johansen simulations
GEMPIE	for printing simulation results
MODHAR	for translating text data files to binary files.
- (2) Utility programs:

SUMEQ	for information about the numerical equations
SUMHAR	for data management
SEEHAR	for data management
CMPHAR	for data management
SLTOHT	for post-solution processing of simulation results

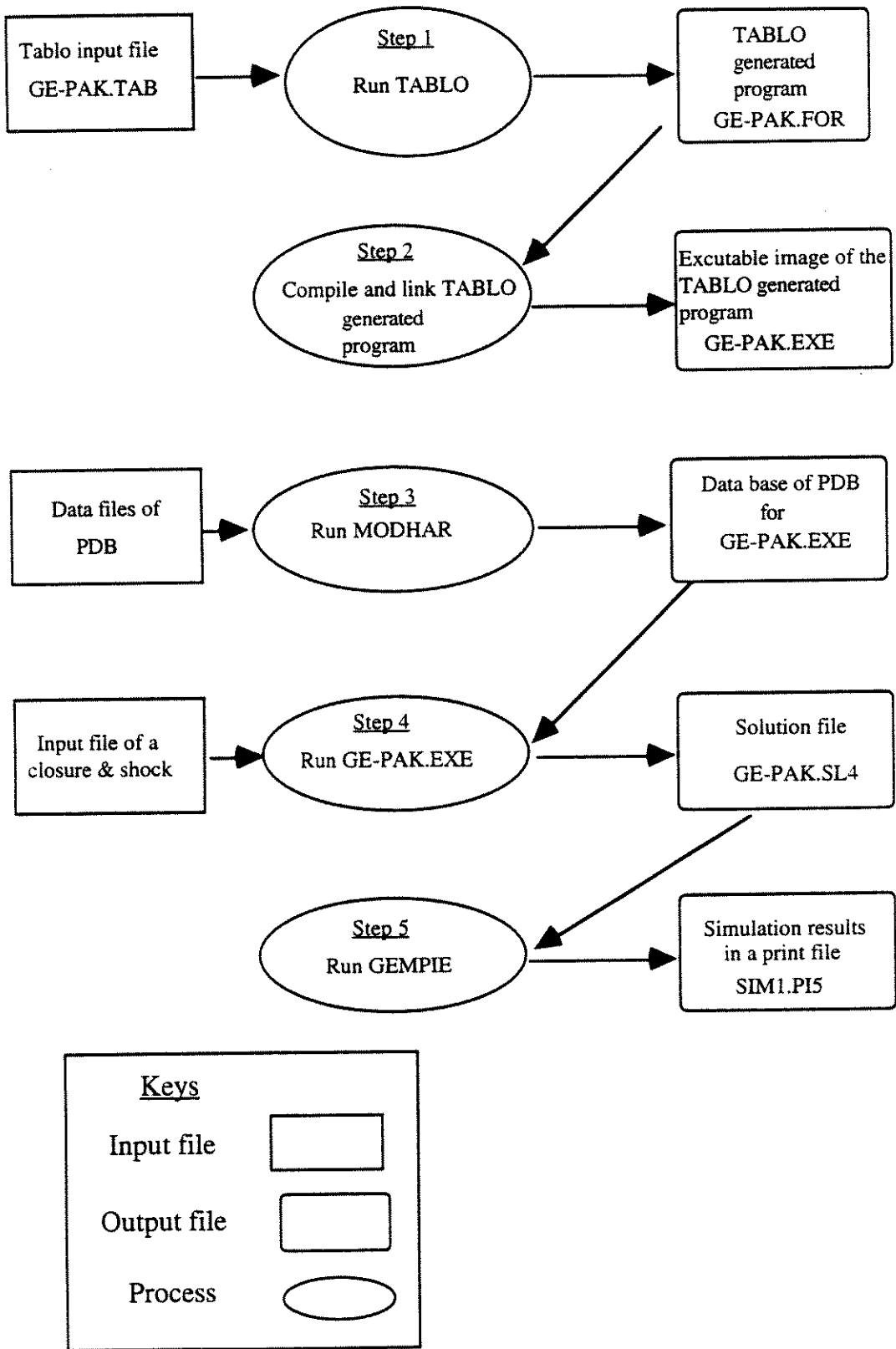
Apart from these programs, there are a number of other programs for transferring a model between different machines (*i.e.*, different operating systems). Further, a computer language is designed that allows us to write equations in an algebraic form. The TABLO program is then used to transfer this algebraic form of the model into a FORTRAN program.

Figure 4.33 shows the steps in computer implementation of GE-PAK using GEMPACK software. In the first step the equations of GE-PAK are written

in an algebraic form; this text file is referred to as GE-PAK.TAB. This is given as an input to the TABLO program which produces a FORTRAN program implementing the model's equations (GE-PAK.FOR). The FORTRAN program is then compiled and linked to generate an executable program (GE-PAK.EXE).

In step 3 (which may be done before step 1 and 2) the Pakistan Data Base (PDB), which is discussed in Chapter 5, is processed by MODHAR to generate a data base which is used by GE-PAK.EXE. In step 4 this program is executed to solve the model. In this step, the closure of the model is defined by choosing the exogenous variables and some of these variables are given exogenous values to define a policy shock. The solution of the model for exogenous changes in some of the variables is stored in GE-PAK.SL4. Since this output file is a binary file, in step 5 we run GEMPIE to generate simulation results in a print file.

Figure 4.33 Steps for Computer Implementation of GE-PAK



Chapter 5

Pakistan's Data Base for Implementation of GE-PAK

5.1 Introduction

This chapter has two objectives. The first is to describe the data base of Pakistan (from now on called PDB) for GE-PAK. The second is to present the parameter values of the model.

As discussed, our model is built around a SAM. We used the 1983-84 SAM (Dhanani, 1986a, 1986b) to construct PDB. The matrix in its original form is not fully suitable for the model. Therefore, we expanded and modified it according to the model's specifications using supplementary data. The SAM was developed in 1986 and is the most recent, comprehensive and consistent data set for Pakistan. However, since 1986 some supplementary data has been published. We used new data to update certain parts of the matrix which were not constructed properly due to lack of information. In Section 5.2 we give a brief introduction to the original SAM. Section 5.3 contains a detailed discussion of changes and modifications made in the original matrix to develop PDB.

In Section 5.4 we present the parameters of the model which were assigned externally estimated values. Various micro level studies have been carried out for Pakistan to estimate production and consumption functions in a partial equilibrium framework. We selected some of the parameters' values from these studies. For the rest of the parameters, where econometric estimates were not available for Pakistan, we used parameter values from other CGE models of developing countries.

We incorporated fourteen changes in the SAM to construct the data base according to the specifications of GE-PAK. A brief summary of these changes is given below.

(1) Disaggregation of Mining Industry.

We disaggregated the mining industry into three industries: oil & gas, coal, and other minerals. We used the statistics given in the *Census of Mining Industries* (GOP, 1988) for this disaggregation. The new industry of oil & gas has two outputs: oil and gas.

(2) Disaggregation of Electricity Sector.

We disaggregated the electricity sector into four industries using supplementary data from the *Power System Statistics* (WAPDA, 1989). The four new electricity industries represent four types of electricity generation plant: hydro, combined cycle, gas turbine and steam generators. The total output value of the electricity industries was corrected to match the value given in the supplementary data from the *Power System Statistics* (WAPDA, 1989) and the *Government Sponsored Corporations* (GOP, 1985a).

(3) Disaggregation of Output of the Refinery Industry.

The refinery industry was made a multiple output industry. Now, it produces six types of petroleum product: kerosene, high speed diesel, light diesel oil, gasoline, furnace oil and other petroleum products. We used supplementary data on the refinery industry from the *Energy Year Book* (GOP, 1989).

(4) Incorporation of Implied Subsidies on Imported Petroleum Products.

The implicit taxes of Rs 1.1 billion on imported petroleum products was not allocated appropriately in the original SAM. In PDB they were allocated to six types of imported petroleum product using the supplementary data from the *Economic Survey* (GOP, 1985b) and the *Energy Year Book* (GOP, 1989).

- (5) Disaggregation of Value-Added into Returns to Labour and Fixed Factor.

In the SAM, value-added in all the small-scale manufacturing industries was shown merely as wages. We disaggregated the value-added in these industries into gross operating surplus and labour wages according to the distribution pattern given in the *Survey of Small and Household Manufacturing Industries* (GOP, 1987).

- (6) Disaggregation of Trade and Transport Margins on Imports.

The values of imports in the SAM were inclusive of trade and transport margins which were assumed to be supplied from the ROW. We disaggregated values of imports into CIF value and margin costs on their supplies. The margin costs now represent the costs of margin goods supplied from domestic sources.

- (7) Removal of Initial Imbalances in the SAM

The difference in the demand for, and supply of ten commodities was eliminated by taking an average of the two and adjusting the SAM using the RAS method (Bacharach, 1970).

- (8) Formation of Indirect Tax Matrices.

The SAM, originally in the purchaser's prices, was transformed into basic prices by making all the intermediate flows net of indirect taxes and margins of trade and transport. The indirect taxes are now given in separate matrices for five users' categories.

- (9) Disaggregation of Indirect Taxes on Imports.

We disaggregated the indirect taxes collected on imports into sales taxes and import taxes.

- (10) Formation of Trade and Transport Margin Matrices.

We developed five matrices which contain trade and transport margins on domestic and imported goods to show margins paid by five user categories.

- (11) Incorporation of Export Subsidies.

We allocated subsidies of Rs 1.3 billion to exports. These subsidies were given in the national accounts, but were not incorporated in the SAM.

(12) Development of Capital Formation Matrix.

In the SAM, a vector of fixed-capital formation showed flows of commodities used for aggregated investment. We disaggregated the total fixed-capital formation by user industries. This disaggregation was made using supplementary data on investments by major sectors given in the *Economic Survey* (GOP, 1985b). The new matrix gives commodities used in capital formation in each industry.

(13) Disaggregation of Returns to Fixed Factor.

We disaggregated returns to fixed factor into two categories. The first category accounts for returns to land while the second category represents returns to fixed capital.

(14) Disaggregation of Capital and Land by Source.

In the SAM, factors of production were owned by the five institutions but industries used only one type of capital and one type of land. We disaggregated rental value of capital in industries into six categories to show the ownership of these factors. Similarly rental value of land was disaggregated into five categories

5.2 Social Accounting Matrix of Pakistan 1983-84

The 1983-84 SAM of Pakistan was developed by Dhanani (1986a, 1986b) at the Institute of Agricultural Economics, Oxford, U.K. It was developed as part of a research program to analyse agricultural policy in Pakistan. The 273×273 matrix was developed by updating a 1975-76 input-output table for Pakistan. The original input-output table was developed by Saleem *et al.* (1983). It is a 118×118 matrix of flows of domestic goods and services with a separate import-absorption matrix of the size 67×118. The input-output table was expressed in purchasers' prices and so was the SAM. At the first stage Dhanani (1986a) updated the input-output table to the

1983-84 financial year. This updated input-output table was used to build up a SAM comprising of the following 12 accounts:

- Wants,
- Factors,
- Domestic current account of households,
- Domestic current account of private corporations,
- Domestic current account of public corporations,
- Domestic current account of government,
- Consolidated capital account,
- Current account of the ROW,
- Capital account of the ROW,
- Production account of domestic commodities,
- Production account of imported commodities, and
- Indirect taxes.

A schematic diagram of the SAM is given in Figure 5.1. According to the standard notion, a SAM is a square matrix in which each column sum is equal to its corresponding row sum. A column gives expenditure entities in an account while a row shows receipts in that account. In Figure 5.1 we have used the names of income and expenditure matrices from the data base format discussed in Chapter 4. The following paragraphs give a brief description of the twelve accounts at an aggregated level (see Dhanani, 1986b, pp. 18-32 for further details).

- (1) The Wants account represents income and expenditure accounts for item formation. In this account income is derived from the sale of consumption items to households. These items are produced by using domestic and imported goods. The first column in the matrix gives this expenditure.
- (2) In the Factors account, factors of production render their services to domestic producers and the ROW. The second row shows payments received for these services. These factors are owned by the five institutions: households, private corporations, public corporations, governments, and the ROW. In the second column, rentals of primary factors are paid to these institutions.

Figure 5.1 Aggregate Social Accounting Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	
	Account Names	Wants	Factors	Households	Private Corporations	Public Corporations	Government	Consolidated Capital Account for Domestic Institutions	Rest of the World Current	Capital	Domestic Commodities	Imported Commodities	Indirect Taxes	Total
1	Wants			VITEM					VYHOUROW		VILAB VICAP_COR + VILND_COR + VICAP_UCOR + VICAP_DWE + VILND_UCOR			
2	Factors													
3	Domestic Institutions	Households	VYHOU LAB VYHOU CAP + VYHOU LND	VYHOUHOU	VYHOU COR	VYHOU COR	VYHOU GOV							
4	Current	Private Corporations	YCORCAP + YCORLND											
5	Account	Public Corporations	YCORCAP + YCORLND											
6		Government	YGOVCAP + YGOVLND	VYGOVHOU	VYGOV COR	VYGOV COR							VOTAX_isj + VOTAR_j	
7	Domestic Institutions	Consolidated Capital Account		VSAVHOU	VSAV COR	VSAV COR	VSAV GOV		VOMAR	LON				
8	Rest of the World	Current	VYROWCAP VYROWLND									VOMIMP + VOMAR		
9	World	Capital							LON					
10		Domestic Commodities	COMITEM				PUR5	PUR2_j	PUR4		PUR1			
11		Imported Commodities	COMITEM				PUR5	PUR2_j			PUR1			
12		Indirect Taxes									VOTAX_j	VOTAX_j + VOTAR		
	Total													

- (3) In the Households' account, income includes the factor earnings, dividends from corporations, and transfer payments from other households and government. The third row shows this income account. The third column shows households' expenditure on consumption items, transfer payments made by them, direct taxes paid to government and savings made by them.
- (4) In the private corporations' account, income is the rental value of factors (row 4). Expenditures are: payments of dividends to households; payments of direct taxes to government; and residual income retained by these corporations as savings (column 4).
- (5) In the public corporations' account, income is the rental value of the factors (row 5). The expenditure is payments of dividends to households and to government, and savings in the form of retained income (column 5).
- (6) In the government account, income is the rental value of factors, direct taxes; from households, private and public corporations, and dividends from public corporations (row 6). The government also receives taxes levied on domestic and imported commodities. The government expenditure account (column 6) consists of transfer payments to households, purchases of commodities for government consumption, and savings of the government.
- (7) There is one capital account consolidated for the four domestic institutions. This account receives savings from all the four domestic institutions (row 7). In the SAM the deficit in balance of payments is shown as loans from the ROW. This loan is also shown as income in the consolidated capital account. The expenditure in the consolidated capital account is purchases of investment goods and services (column 7).
- (8) There are two accounts for the ROW: current and capital. The current account receives payment for factor services and imports (row 8). The expenditure in the ROW's current account is payments for employing

primary factors from Pakistan, purchases of commodities from Pakistan and the loans given to Pakistan to meet the deficit in the balance of payments (column 8).

- (9) Income in the Capital account of the ROW is equivalent to the difference between earnings and spending of foreign currency in the current year, *i.e.*, the deficit in the balance of payments (row 9). The expenditure in this account is transfer of this money to the consolidated capital account of the domestic institutions (column 9).
- (10) Income in the Production account for domestic commodities is from sales of these commodities to five accounts: wants, government, the ROW and current goods producers (row 10). Expenditure in this account is costs of primary factors and intermediate inputs to produce domestic commodities (column 10). Since the SAM is in purchaser's prices, expenditure also includes indirect taxes as part of production costs.
- (11) The income account for imported commodities receives payments for selling imported goods and services to various accounts (row 11). The expenditure account shows purchase of imported goods and services from the ROW and indirect taxes paid on them (column 11).
- (12) There are two Indirect-tax accounts: taxes on domestic commodities and taxes on imported commodities. The income in an indirect tax account is receipts of indirect taxes (row 12). The corresponding column shows the transfer of indirect taxes to government.

Dhanani (1986a, 1986b) discussed, at great length, the development of the SAM and various sources of data.

5.3 Development of PDB

As mentioned, we incorporated fourteen changes in the SAM to develop PDB. We discuss these changes in detail in Subsections 5.3.2 to 5.3.15. Subsection 5.3.1 discusses the procedure which was adopted to incorporate the changes in the SAM.

5.3.1 Strategy for Development of PDB

We incorporated the fourteen changes in the SAM in three separate stages.

- At the first stage we adjusted the original SAM for any discrepancies found in it (for example changes number 5 and 7). We used the national macroeconomic aggregates as control values; to be preserved, while removing any discrepancy in the income and expenditure of any account. The target values of private consumption (C), public consumption (G), imports (M), exports (X), fixed-capital formation (I) and net indirect tax revenues on domestic and imported commodities (TAXREV) for 1983-84 were taken from the *Economic Survey* (GOP, 1985b). Thus we allowed adjustment in the value added (V1PRM) to satisfy the GDP identity:

$$C + G + INV + EXP - IMP = V1PRM + TAXREV \quad (5.3.1)$$

Dhanani also used the same values of macroeconomic aggregates as target values while developing the SAM. However, he underestimated total value-added by about Rs 15 billion, because imports were measured in purchasers' prices. Tables D1 to D3 in Appendix D compare GDP components given in the SAM with those from the *Economic Survey* (GOP, 1985b).

- At the second stage we expanded the adjusted SAM to incorporate new energy industries.
- At the third stage, changes (such as disaggregation of domestic and import taxes) were incorporated to fit the data base into the overall framework of our model given in Figure 4.3 in Chapter 4.

Application of the RAS Method

After incorporation of every change in the SAM, we used the well-known RAS method to produce a new balanced SAM; with row totals equal

to column totals. Two sets of FORTRAN program¹ were used to keep the SAM balanced. The first program uses a subroutine (RAS_SUB) that updates a square matrix by making column and row sums equal to the given target values using the following equation:

$$BNEW_{ij} = \lambda_i B_{ij} \beta_j, \quad \text{s.t.} \quad \sum_i BNEW_{ij} = CT_j, \quad \text{and} \quad \sum_j BNEW_{ij} = RT_i, \\ i \in \text{COM}, j \in \text{IND}, \quad (5.3.2)$$

where B_{ij} is the original square matrix and λ_i and β_j are scaling vectors which produce the new matrix BNEW. The vector CT_j contains the target value of row sum for column j . Similarly, the vector RT_i contains the target value of column sum for row i .

The SAM did not remain square after disaggregation of the mining and electricity industries and incorporation of multiple products in the refinery industry. Some industries produce more than one output and some commodities are produced by more than one industry. For example, the refinery industry produces six commodities. The second FORTRAN program (ALTRAS) found scale factors λ_i and β_j such that

$$BNEW_{ij} = \lambda_i B_{ij} \beta_j, \quad i \in \text{COM}, j \in \text{IND}, \quad (5.3.3)$$

s.t.

$$\sum_{i \in \text{COM}} BNEW_{ij} = C_j, \quad (5.3.4)$$

$$\sum_{j \in \text{IND}} BNEW_{ij} = R_i, \quad (5.3.5)$$

$$\sum_{i \in P(j)} R_i = C_j, \quad (5.3.6)$$

where $P(j)$ is the set of rows associated with column j and

$$\sum_{j \in Q(i)} C_j = R_i, \quad (5.3.7)$$

where $Q(i)$ is the set of columns associated with row i .

¹ These FORTRAN programs are available from Dr. Mark Horridge who prepared these programs.

As mentioned, another concern in the development of PDB was to keep the values of selected macroeconomic variables (such as GDP or exports' earnings) comparable to their values given in the national accounts. In the application of the RAS method at the first and the second stage, these macroeconomic aggregates were computed from the adjusted matrix after every iteration. The relevant parts of the adjusted the SAM were then scaled to resolve any discrepancies in the control values and the new values of macroeconomic variables.

5.3.2 Disaggregation of Mining Industry

The *Census of Mining Industries of Pakistan* (GOP, 1988) gives 1983-84 statistics on inputs and outputs of six major categories of minerals, including oil, gas, and coal. The total output value of the mining industry in the census is not equal to that in the SAM. Therefore, the distribution pattern of inputs among the sub-sectors reported in the census is used to disaggregate input flows in the SAM to disaggregate mining industry into three parts. The sum of inputs consumed by each of the mining industries was used to calculate the first estimate of its output.

On the demand side, output of the mining industry given in the SAM was disaggregated into usage of crude oil, raw natural gas, coal and other minerals on the following assumptions:

- inputs from the mining industry to the refinery and to the gas processing industries are solely oil and gas respectively;
- input supply to produce the consumption item "coal" is all coal;
- input supplies to all other industries are coal and other minerals. The ratio of coal to other minerals is equal to the ratio of estimated output of coal and other minerals.

The initial estimates of supplies from the three new mining industries and the assumed demand for the four commodities were not in balance. Production of coal and other minerals was much lower than estimated consumption. According to one of the studies on the coal industry (See Khan *et al.*, 1986),

about 50 per cent of coal industry's output is not reported. Assuming the same level of under-reporting for the other mineral's industry, the estimated outputs of these two industries were increased by 50 per cent. After subtracting the new estimates of the two products from the total output of the mining industry, the remaining output was disaggregated into oil and gas according to their ratios in the census. The average of consumption estimates and the new output levels were used as target values for column sum and row sum in the application of the RAS method to balance the SAM. The SAM was then scaled using the RAS method. The shares of the three energy industries in the values of inputs, output and the indirect taxes are given in Table 5.1.

Table 5.1 Input Distribution Pattern of the Mining Industries
in the Pakistan Data Base (PDB)

	(1)	(2)	(3)	(4)	(5)	(6)
Industries	Employ- ment Cost (%)	Industri- al Cost (%)	Indirect Taxes (%)	Value Added (%)	Returns to Capital (%)	Gross Value of Production (%)
Coal	48.5	38.1	3.2	14.0	14.3	19.3
Oil & gas	6.1	17.9	78.1	30.4	20.5	27.6
Others minerals	45.4	43.9	18.7	55.6	65.2	53.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

5.3.3 Disaggregation of Electricity Sector

In Pakistan there are four types of electricity plant (hydro, combined cycle, steam generator and gas turbines). Disaggregation of output by type of plant is important due to differences in the shares of capital cost and fuel costs for hydro and thermal plants. Further, the type of fuels used to generate electricity varies among the thermal power plants. While the combined cycle and steam plants use natural gas and furnace oil, the major fuel for gas turbines is high speed diesel. The *Power System Statistics* (WAPDA, 1989)

gives the break up of cost per kilowatt hour in nine major electricity plants for five cost categories: (a) interest charges, (b) depreciation charges, (c) establishment charges, (d) maintenance charges and (e) fuel charges by type of fuel, *i.e.*, natural gas, furnace oil and high speed diesel (Table 1.11 in WAPDA, 1989). Table 1.23 in the *Power System Statistics* (WAPDA, 1989) shows electricity generation in KWH from each plant. This supplementary data on cost and generation were used to disaggregate the electricity sector in the SAM. Since the cost categories in the supplementary data and the SAM were not the same, we made the following assumptions about the costs categories in the supplementary data:

- interest payments and depreciation charges represent rental value of capital;
- establishment charges represent payments to labour;
- maintenance costs represent inputs from services industries. We made this assumption because in the SAM all intermediate inputs (other than fuels) in the electricity sector were supplied by the services industries); and
- fuel costs are inputs from the corresponding fuel-producing industries.

In the supplementary data, the nine major electricity plants consist of three hydro electricity plants, one combined cycle plant, three plants with steam generators, and two with gas turbines. We computed the output value of each plant using the production cost per unit of output and units of electricity produced by that plant. The inputs and output by plant types were then aggregated to arrive at an input-output table of the four electricity industries. From this input-output matrix of 6×4, we then computed an input distribution matrix that shows the shares of the four electricity industries in each input. Table 5.2 gives this distribution matrix. We disaggregated the electricity sector of the SAM (with single industry) into a sector of four industries using the following formula:

$$SAM_{ij} = D_{ij} \times SAM_{i, \text{electricity}}, \quad \therefore \sum_j D_{ij} = 1, \quad (5.3.3.1)$$

j = hydro, combined cycle, steam generator, gas turbine industries,

i = rental value of capital and labour, intermediate inputs of three types of fuel and services, and

D = input-distribution matrix.

Table 5.2 Disaggregation of Electricity Sector

	(1)	(2)	(3)	(4)	
		Combined			
Production Cost Category	Hydro electricity	cycle electricity	Steam electricity	Gas turbine electricity	Total
Labour	0.25	0.09	0.54	0.12	1.0
Capital	0.47	0.30	0.17	0.06	1.0
Petroleum products	0.00	0.54	0.26	0.20	1.0
Gas	0.00	0.14	0.46	0.40	1.0
Maintenance	0.37	0.16	0.36	0.11	1.0

Note: Based on Table 1.11 and Table 1.23 in WAPDA (1989).

In updating the input-output table for 1983-84, gross values of output in the construction and services industries were arrived at by applying the growth rates in their value added during the 1975-76 to 1983-84 period, as given in the *National Accounts* of 1975-76 (GOP, 1976) and 1983-84 (GOP, 1985c). The detailed data on inputs and output of electricity industry are given in the *Power System Statistics* (WAPDA, 1989) and in the report on *Public Corporations* (GOP, 1985a). The gross values of electricity output in 1983-84 (WAPDA, 1989) of Rs 11.3 billion is about 40 per cent higher than the Rs 6.6 billion arrived at in the SAM. The comparison of gross values in 1975-76 given in the *Power System Statistics* (WAPDA, 1989) with that taken by Dhanani (1986a, see Table 2.10, pp. 26) shows that the value of electricity output was underestimated by 23 per cent in that year too. To rectify this underestimation we set the gross value of output in the electricity industry to Rs 11.3 billion in the new SAM and used the RAS method to eliminate resulting discrepancies.

5.3.4 Disaggregation of Petroleum Products

In the original SAM, the refinery industry was treated as a single output industry. The *Energy Year Book* (GOP, 1989) gives statistics on production, imports and exports of six types of petroleum product. We used this supplementary data source to disaggregate the output of refinery industry and its exports into six products. Similarly, aggregated imports of petroleum products was also disaggregated into six types of product. The *Energy Year Book*, (GOP, 1989) contains detailed data on volumes of production, imports and exports for six types of petroleum product, and their prices. From this data, we calculated shares of six types of product in the total values of production, imports and exports to disaggregate corresponding aggregated values in the SAM.

On the consumption side, the SAM already contained usage of petroleum products in households by product type. We took shares of petroleum products in their aggregate export values from the *Energy Year Book* (GOP, 1989). There was no reliable data on intermediate and government usage of petroleum products by type. The statistics published by the Oil Company Advisory Committee (OCAC, 1988) allocates petroleum products to major industry groups, *i.e.* agricultural, manufacturing, transport and electricity industries. There are three major problems with this usage distribution: (i) usage of high speed diesel in the transport industry includes its consumption by tractors in the agriculture industry; (ii) gasoline consumption by households for private transportation is treated as usage by the public transport industry; (iii) no allowance is made for use of petroleum products in the construction and the services industries. In a research study on energy demand forecasting, Khan *et al.* (1986) have estimated fuel use by agricultural tractors and fuel usage by the service and construction industries. In their study, estimates of fuel usage are also made for four modes of transportation, *i.e.*, rail, road, water and air. In line with these estimated shares, we prepared a distribution pattern to split the refinery output used in each industry into six types of petroleum products (see Table 5.3).

Table 5.3 Consumption Pattern of Petroleum Products

Users	Kerosene	High speed diesel	Light diesel oil	Gasoline	Furnace oil	Others
Households (kerosene)	1.0	0.0	0.0	0.0	0.0	0.0
Households (Non-Durable Transport)	0.0	0.1	0.0	0.9	0.0	0.0
Exports	0.0	0.0	0.0	0.0	0.4	0.6
Agriculture	0.0	0.8	0.2	0.0	0.0	0.0
Mining and manufacturing	0.0	0.3	0.1	0.0	0.6	0.0
Construction	0.0	1.0	0.0	0.0	0.0	0.0
Hydro electricity	0.0	1.0	0.0	0.0	0.0	0.0
Combined cycle electricity	0.0	1.0	0.0	0.0	0.0*	0.0
Steam electricity	0.0	0.0	0.0	0.0	1.0	0.0
Gas turbine electricity	0.0	1.0	0.0	0.0	0.0	0.0
Gas processing	0.0	0.5	0.0	0.0	0.5	0.0
Whole sales & retail	0.0	1.0	0.0	0.0	0.0	0.0
Road transport	0.0	0.8	0.0	0.2	0.0	0.0
Rail transport	0.0	0.5	0.0	0.0	0.5	0.0
Air transport	0.0	0.0	0.0	0.0	0.0	1.0
Water transport	0.0	1.0	0.0	0.0	0.0	0.0
All others users	0.0	0.5	0.0	0.0	0.5	0.0

*In the combined cycle furnace oil can be used in place of natural gas but in our base year data consumption of furnace oil in combined cycle is zero.

We assumed that the same split applies to both imported and domestic petroleum products. The resulting pattern of consumption was then mapped to the computed production and import pattern of these products. Since the

estimated demand pattern did not match the computed supply pattern, the two were reconciled by using the RAS iterative process.

In the SAM, indirect taxes on commodities were included as part of production costs. Thus there was a single tax revenue entry in the refinery industry's costs account which showed the aggregated net taxes on the six petroleum products. In the *Energy Year Book* (GOP, 1989) the structure of the retail prices is given for five petroleum products. This structure reports each component of these prices. As discussed in Chapter 2, there are two types of taxes on petroleum products. Customs or excise duty is levied on some of the products only. Another tax is the "development surcharge" which is calculated as the difference between the cost of supply (including trade and transport margins) and the fixed sale price of a product. Using these two types of tax rate and production volumes, we estimated indirect tax revenues on each product. The computed tax and sales revenues for each product were used to estimate tax rates by product type. The sales values of six petroleum products in the updated SAM are averages of their computed supply and demand values. Therefore tax revenues generated by applying the computed tax rates from the supplementary data do not sum up to the total sales tax revenues given in the SAM. Thus to arrive at total sales tax revenues of the SAM, we first computed a ratio of the two sums. We then scaled the set of computed tax rates by that ratio.

5.3.5 Incorporation of Implied Subsidies on Imported Petroleum Products

As mentioned in Chapter 2, sales prices of petroleum products are set by the government of Pakistan. These prices also apply to imported products. If the average cost of an imported product differs from its set price, the gap is paid by the government. Thus there is an implicit tax (if import cost is lower than the set price) or a subsidy (if import cost is higher) on the imported products. We used the supplementary data from the *Energy Year Book* (GOP, 1989) to allocate the implicit tax revenues on imports by product type. First, total tax revenues for the six imported petroleum products were computed

using the supplementary data on volumes of imports, sale prices and import costs. The two sums of estimated tax revenues on domestic and imported products given in the SAM were comparable to our estimates. However, the split between sales and import taxes in the SAM was not comparable to our estimates. Sales tax revenues on petroleum products in the SAM were higher than the computed revenues from the supplementary data. Therefore sales tax revenues of about Rs 993 billion were reallocated to the import tax revenues to account for the implied taxes and subsidies on them.

5.3.6 Splitting of Value Added into Returns to Labour and Fixed Primary Factor in Small-Scale Manufacturing Industries

In the SAM, it was assumed that returns to fixed factors (capital and land) are zero in all the small-scale manufacturing industries. Dhanani faced a problem in allocating value added between fixed factor and labour in these manufacturing industries. His computed total wage bill in these industries was much higher than their total value added (see Dhanani, 1986a p. 71).

We disaggregated value added in these industries between labour and fixed factor using the *Survey of Small and Household Manufacturing Industries of 1983-84* (GOP, 1987). This survey gives value added, number of workers, and employment cost for the major industries. Except for a few industries, the grouping of the industries in the survey is identical to that used in the SAM. One distinguishing feature of these industries is their employment structure. In the employment statistics two types of labour are given: unpaid workers (self-employed), and paid workers. Since the small-scale manufacturing activities are mainly carried out by self-employed persons, a small fraction of the labour is hired. According to the survey, on aggregate about 35 per cent of the labour was paid in these industries. Statistics are also given on the numbers of paid and unpaid workers for each industry along with payments made to the paid workers. First we computed an average wage rate for paid workers in each industry. Then, labour costs were imputed for paid and unpaid labour in each industry assuming that wages to the unpaid workers were the same as those for paid workers. The

total value-added of these industries in the survey (Rs 11.1 billion) was not equal the value added (Rs 15.1 billion) reported in the SAM. Therefore, we computed shares of imputed labour costs (including imputed cost of unpaid labour) in total value-added for these industries. Table 5.4 shows these shares by major industries. We applied these shares to disaggregate the value-added of each industry in the SAM.

This procedure of disaggregating value-added is in line with the procedure adopted by Dhanani to compute household's income by source. In Dhanani's estimation, the wage earnings of a self-employed person are purely returns to his labour and the rest of his earnings is return to capital that he owns. As stated by Dhanani (1986a, pp. 58-59), "Finally, the distinction between wages and unincorporated business income highlighted the fact that a proportion of self-employed people received payments for factor services other than labour as well as an implicit wage component. Their incomes as recorded in the *Household Income and Expenditure Survey* (GOP, 1983) did not make such a distinction, and it was therefore necessary to impute a wage for such workers, and to interpret the difference between this imputed wage and their total factor income as a payment of the factor 'unincorporated business capital.'".

Table 5.4 Shares of Labour in Value Added
of Small-Scale Industries in the PDB 1983-84

Industry	Share of Labour in Value Added
SS*-grain milling	0.49
SS-rice husking	0.49
SS-gur and raw sugar	0.49
SS-edible oils	0.49
SS-other food industries	0.49
SS-beverages	0.49
SS-tobacco	0.63
SS-cotton textile	0.65
SS-silk and art-silk textiles	0.65
SS-carpets	0.65
SS-other textiles	0.76
SS-shoe making	0.64
SS-wood	0.65
SS-furniture	0.66
SS-steel furniture	0.61
SS-printing and publishing	0.62
SS-leather products	0.49
SS-rubber goods	0.55
SS-chemicals	0.60
SS-plastic products	0.44
SS-non-metallic minerals products	0.49
SS-iron and steel remoulding	0.48
SS-metal products	0.61
SS-agricultural machinery	0.61
SS-non-electrical machinery	0.75
SS-electrical machinery	0.60
SS-transport equipment	0.46
SS-sports goods	0.58
SS-surgical instruments	0.53

* Small Scale

Note: Based on the *Survey of Small and Household Manufacturing Industries*, GOP(1987).

5.3.7 Valuation of Imports in Producer Prices

In the development of the 1983-84 SAM, Dhanani aimed at comparability of aggregate values of private and public consumption, investments, exports, imports and taxes in the SAM with those given in the *national accounts* (see Dhanani 1986b, pp. 21-32). The national accounts' statistics on income and expenditure given in the *Economic Survey* (GOP, 1985) and in the SAM are summarised in Table D1 and Table D2 respectively. The comparison of national accounts' statistics on the expenditure side of GDP shows that the total values of private and public consumption, fixed-capital formation, and exports in the SAM are exactly equal to the figures given in the national accounts. The total value of imports, however, is higher than the national accounts figure by Rs 15 billion because they were valued at purchaser's prices in the SAM. As a result, the value of domestically produced goods was lower by the same amount. Further, subsidies on exports were not subtracted from total net indirect taxes due to measurement of exports in purchaser's prices. For these two reasons, income side data on GDP (factor prices and total indirect taxes) did not match the national accounts. Thus, due to accounting of imports and exports in purchaser's prices, GDP was underestimated by about Rs 22 billion.

To compute imports at producer prices, we divided import values into CIF costs, and trade and transport margins. In the SAM we decreased the value of imports in the imports account by Rs 15 billion; this value was shown as purchase of inputs from the domestic trade and transport industries to the import account. The estimation of trade and trade margins for each imported commodity is discussed in Section 5.3.11.

The SAM contained trade and transport margins on imports as a transfer payment to the ROW from the consolidated savings of the nation (see Figure 5.1). To correct this, we increased the value of GDP in the SAM by Rs 15 billion and showed it as domestic savings to keep the values of consumption and investments intact. In this paragraph we discuss the procedure adopted for this modification. After incorporating domestically

produced trade and transport margins we set the transfer payments from the consolidated savings accounts to zero. Initially, we increased the total value added in the margin-goods industries by Rs 15 billion in their initial proportions. At the same time the gross output values of the margin-goods industries were increased by Rs 15 billion. To match this increase in the value added, we also increased savings of the three domestic institutions in proportion to their initial share in total savings. The RAS routine made further adjustment by increasing inputs to the trade and transport industries to match the required output level. It also increased the value added in other industries according to their shares in supplies of inputs to the trade and transport industries.

5.3.8 Removal of Initial Imbalances in the SAM

In the development of the SAM, the gross value of output was estimated first by updating 1975-76 input-output tables for major industries using national accounts data on production and prices in 1975-76 (GOP, 1976) and 1983-84 (GOP, 1985). The values of final and intermediate consumption and value added were then derived from the estimated gross value of output using the ratios of these components in the input-output table of 1975-76. The difference in the estimated gross national products at market prices and the expenditure on them was accounted for as changes in inventories. As a result, there were a large outflow from inventories in 10 industries out of 118. The intermediate demands in these industries were much higher than the expected value of intermediate inputs required for initial estimates of outputs of these industries. According to Dhanani (1986b, p. 61):

"A similar situation occurred in the 1975-76 (input-output) Table. These observations, together with the fact that most of these industries were related to large-scale textile manufacturing, may make the estimates of gross values of output in the textile division given in Section 2 somewhat suspect. However, in the absence of additional data on the gross values of output of large-scale textile manufacturing besides those given in Section 2, it was

thought prudent to represent the 1983-84 input-output table with the above negative stock changes included in it, as was the case in the 1975-76 Table."

Thus the expenditure account was made compatible with the national statistics by assuming a contraction in inventories.

Further, in some of the industries there was a small positive stock change. In GE-PAK, changes in inventories are not modelled and investment represents fixed-capital formation only. Therefore we balanced our benchmark data assuming that changes in inventories are zero. Thus value added is adjusted to match the output of commodities destined either for final or for intermediate use.

At the first stage of adjustment of the SAM, we excluded the values of inventory changes from the fixed-capital formation vector. This led to a big difference in the supply and demand of 10 industries which initially had supply-demand discrepancies. The RAS procedure was then applied to the SAM. Outside the problem industries, values of the RAS scaling factors were between 4 and 6 per cent.

5.3.9 Formulation of Tax Matrices

Our model needs production and consumption accounts to be in producers' prices, with indirect tax components recorded separately. We transformed all flows in the SAM from purchasers' prices into producers' prices and added a set of indirect tax matrices. Jetha, Akhtar and Rao (1984) gave a detailed description of Pakistan's direct and indirect tax revenues for 1981-82. Dhanani used their study to prepare two indirect tax accounts in the SAM; indirect taxes on domestically produced commodities and indirect taxes on imported commodities. In Pakistan there are three types of indirect tax: excise or import duty, sales taxes, and surcharges. In economic terms there is no difference between these categories. The administrative distinction is that excise duty is levied on domestic production, and import duty is levied on imports. In both categories some commodities are taxed at specific rates and the remainder at *ad valorem* rates. The sales tax is a single-

stage tax levied on imports as well as domestically produced goods. The third type of tax— surcharge— is only levied on fertiliser, natural gas and petroleum products, and is designed to siphon off surplus profits representing the difference between the cost of production and the fixed sale price of these commodities, or between the average import price and the prescribed sale price of similar locally manufactured goods (see Jetha *et al.*, 1984, p. 12).

As mentioned earlier, Dhanani aggregated various types of indirect tax revenues collected on a domestic commodity and showed the sum as a cost of production of that commodity. Similarly for imported commodities, indirect taxes were included in the cost of supply. Our model distinguishes only two types of indirect taxes: (i) sales taxes which are levied at an *ad valorem* rate on a commodity irrespective of its source of supply (imported or domestically produced); (ii) import taxes which are levied only on imports of a commodity.

To compute tax revenue matrices from the SAM, we first computed a vector of tax rates on domestic commodities from the SAM. The tax rate on output of industry j was defined as:

$$\text{Tax rate}_j = \frac{\text{Tax revenues}_j}{\text{Gross Value of Output}_j - \text{Exports}_j}, \quad j \in \text{IND. (5.3.9.1)}$$

Since all exports and the inputs used to produce them are exempted from tax we have computed the tax rate net of exports. This tax rate was then used to compute tax matrices. Each tax matrix contains the tax component in the sale value of commodity j consumed by a users group. For example, the matrix of intermediate inputs PUR1 from Figure 5.1, given in purchasers' prices, is disaggregated into two matrices. One matrix gives basic values of intermediate goods, V1BAS, and the second matrix, V1TAX, gives indirect tax paid on these intermediate inputs using the following equations:

$$\text{V1TAX}_{isj} = \text{PUR1}_{isj} \times \text{TAXRATE}_j, \text{ and} \quad (5.3.9.2)$$

$$\text{V1BAS}_{isj} = \text{PUR1}_{isj} - \text{V1TAX}_{isj}, \quad s = \text{domestic}, i \in \text{COM}, j \in \text{IND. (5.3.9.3)}$$

The above procedure was applied to divide the matrices of purchasers' values of commodities used for capital creation, items formation, and government

consumption. In these computations, we assumed that tax rates are the same for all users groups.

In these computation we also assumed that all taxes were charged at *ad valorem* rates due to the lack of detailed data and for the sake of simplicity. In the original data on taxes some of the commodities had both excise duty and sales tax,: excise duty is levied at specific rates, sales tax at *ad valorem* rates. In PDB development we simply assumed a single *ad valorem* tax rate for each commodity.

This simplification will not greatly affect our analysis. The tax collection from excise duties in 1983-84 at specific rates was about 40 per cent of the total indirect tax revenues from domestic commodities. There were four commodities that made major contributions. Three of them, (cement, edible oil and petroleum products) contributed 25 per cent; the remaining 15 per cent was from all other commodities. The prices of cement, edible oil and petroleum products are fixed by the government. So the issue is not whether taxes on them are levied at specific rate or *ad valorem* rates. Jetha *et al.* (1984, p. 48), in their analysis of Pakistan's tax system, made a similar comments:

"In Pakistan, specific rates and the Government's pricing policy are closely related, and the conversion of specific rates into *ad valorem* rates may not help much unless accompanied by a modification of the pricing policy."

The tax formulae given in equation (5.3.9.1) apply only to single product industries. For multiple-product industries, *i.e.*, the refinery and oil & gas industries, we used the tax revenues collected on each of these products which are given in the supplementary data. For petroleum products, first total tax revenues from the refinery industry was computed using the supply quantity and tax rate on each product given in the *Energy Year Book* (GOP, 1989). The shares of petroleum products in the total tax revenues from them were then applied to disaggregate the tax revenues for the refinery industry given in the SAM.

Similar computations were made for the mining industries, using the tax revenues on crude oil, raw natural gas, coal, and other minerals given in the *Census of Mining Industries* (GOP, 1988) respectively. In the above discussion on the splitting of the mining industry and disaggregation of the refinery industry's output, we mentioned that there were some imbalances between the estimated production and consumption of the new commodities. Since these imbalances were removed by using the RAS, the composition of the resulting supplies of new commodities is not exactly equal to that given in the supplementary data. Therefore, the computed tax components on the four mining industries' output and on the six petroleum products were adjusted to produce the tax rates given in the supplementary data. We first computed tax revenues on sales of each of these commodities using the tax rate given in the supplementary data. These revenues were then scaled to match the computed tax revenues in the SAM.

We applied similar methods to split imports valued at purchasers' prices into basic values and indirect tax components. To begin with we assumed that there is only one type of tax on imports. We computed a tax rate vector for imported goods. We applied these tax rates to compute tax revenues paid by each user on the purchase of imported good. These tax revenues were then subtracted from the total purchase value of the imports for each user. Once we had derived the indirect tax revenues for imported commodities, we disaggregated them into sales tax revenues and import tax revenues. The method of this splitting is discussed in the next paragraph.

5.3.10 Splitting the Taxes on Imported Commodities into Sales and Import Taxes

The tax revenues on imports in the SAM were the sum of sales tax and import tax revenue. We computed these two categories of revenues on imports by disaggregating the total tax revenues on imports using the following equations:

$$V1TAX_{isj} = V1BAS_{isj} \times T0_{ij}, \quad i \in \text{COM}, s=\text{imported}, j \in \text{IND}. \quad (5.3.10.1)$$

$V1TAX_{isj}$ is the imputed tax revenue on imported good i , $V1BAS_{isj}$ is the basic value of good i import, and $T0_{ij}$ is the sales tax rate on good i domestically produced. We computed sales tax matrices for all consumers using the above equation. We then calculated the import tax revenue vector $V0TAR_i$ according to the following formula

$$V0TAR_i = IMPORTS\_TAX_i - V1TAX_{jis} - V2TAX_{jis} - V3TAX_{is} - V5TAX_{is},$$

$$s = 2, i \in COM, (5.3.10.2)$$

where $IMPORTS\_TAX_i$ is the vector of total indirect taxes on imports given in the SAM.

Thus, if the imputed sales tax revenues on imports and total import tax revenues were equal then there was no import tax on the imported commodities and commodities from both the sources were equally taxed. There was an import tax on a commodity if total import tax revenues were higher than the imputed sales tax revenues on imports; implying a bias against the imported commodity. With this method, the resulting import tax rate became negative only if there was a tax on a domestic good but no equivalent tax on the import of that good.

5.3.11 Matrices of Trade and Transport Margins

The rates of trade and transport margin on supply of domestic goods were given by Dhanani (1986a, Table 2.5, p.19) only for the large-scale manufacturing industries. Lacking these rates for all other industries, we estimated trade and transport margins on each commodity by assuming that all sales from wholesale & trade, road transport, and rail transport industries to other industries were margins' costs which were paid by the buyers of output of the later industries. Thus we assumed uniform rates of margins on the supply of a commodity for final and intermediate usage.

We first estimated average rates of margin costs

$$MARGIN\_RATE_{ij} = \frac{X_{ij}}{COSTS_j}, \quad i \in MAR, j \in IND, (5.3.11.1)$$

where $COSTS_j$ is the production cost in industry j (inclusive of the costs of margin goods) given in the SAM and X_{ij} is the cost of margin-good i used in industry j . This margin rate, $MARGIN\_RATE_{ij}$, was applied to compute matrices of margins on sales of commodities to all users using the following equations.

$$V1MAR_{isj} = (PUR1_{isj} - V1TAX_{isj}) \times MARGIN\_RATE_{ij},$$

$i \in MAR, s = \text{domestic}, j \in IND. (5.3.11.2)$

$$V1BAS_{isj} = PUR1_{isj} - V1TAX_{isj} - V1MAR_{isj},$$

$i \in MAR, s = \text{domestic}, j \in IND. (5.3.11.3)$

Here, $PUR1_{isj}$ is the purchasers' price matrix given in the SAM for current goods producers. Similarly matrices of margins and basic values were computed for all other user groups.

The SAM contained sales of the three margin goods to the services industries. We assumed that these margin goods are directly used by these industries.

The average margin rates on imports are given by Dhanani (1986a). Dhanani used these rates to add margins into the value of imported goods at domestic currency prices. We used these rates to first compute a vector of aggregate margin costs on imported commodities. These aggregate margins were then divided into three parts: wholesale & trade, rail transport, and road transport. We assumed that the shares of the three types of margin goods were similar to those for domestically produced goods.

5.3.12 Incorporation of Subsidies on Exports

According to the *Economic survey* (1985b) net indirect tax revenues were Rs 45.4 billion in 1983-84. In the SAM, net indirect tax revenues were Rs 47.8 billion; which was higher than that the value given in the *Economic survey* by Rs 2.4 billion. This difference was due to exclusion, from the SAM, of the net export subsidies (Rs 1.3 billion) and of the implied subsidies on petroleum products (Rs 1.1 billion). The export subsidies were not accounted for because exports values were represented in purchasers' prices and their FOB values were reported. We assumed that the share of an exported commodity in total subsidies was in proportion to its share in total exports

because data on net-export-subsidies by commodities are not available. The estimated average rate of export subsidy was about 13 per cent. To begin with we increased the values of all the exports by the amount of the subsidy. The subsidy was then shown as a negative tax on exports. In this way the SAM remained balanced.

5.3.13 Development of Capital Formation Matrix

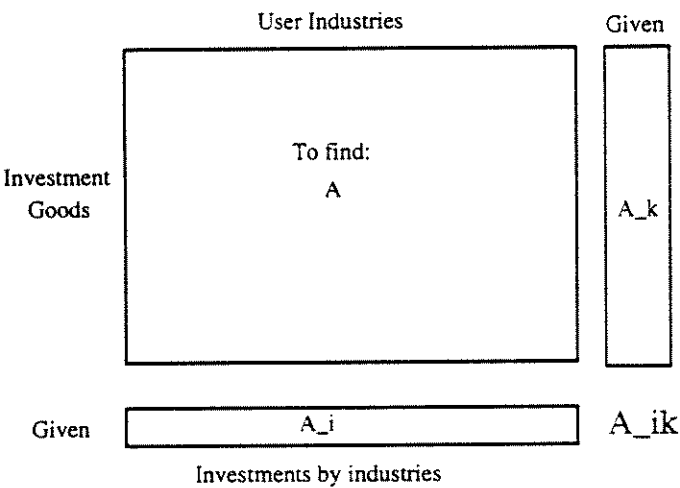
As shown in Figure 5.1, sales of investment commodities were not distinguished by user-industries in the SAM. There, the matrix of fixed-capital formation, $PUR2_{jis}$, shows consumption of investment good i , from source s , for overall fixed capital formation in the economy. We constructed a three-dimensional matrix, $PUR2_{isj}$, that gives flows of investment goods by commodities and by user-industries in which these commodities were used for fixed-capital formation. We split total investment among industries using the following equation:

$$PUR2_{isj} = PUR2_{jis} \frac{A_{isj}}{\sum_{j \in SEC} A_{isj}}, \quad i \in INVCOM, s \in SRC, j \in SEC, (5.3.13.1)$$

where SEC is a set of major industry groups, and $INVCOM$ is a set of commodities used for investments. The A_{isk} is an input-output matrix of investment prepared from supplementary data. The *Economic Survey* (GOP, 1985, p. 31) contains data on fixed-capital formation in fifteen groups of industries for 1983-84. Dhanani took values of aggregate capital formation from the same data set (Dhanani, 1986b, Table 4.1, p. 55) to form the matrix of fixed capital formation while constructing the SAM. Thus in the supplementary data, sum of investment goods (over commodities) is equal to the sum of investments (over industries). In the SAM, out of 118 domestic goods and 72 imported goods, only 30 goods were used for investment purposes. Thus from the SAM we had vector A_{k_i} for 30 investment goods and from the supplementary data a vector of investments, A_{i_k} , by 15 major groups of industries. As shown in Figure 5.2, our task was to fill in the matrix A in such a way that the row sums equalled the given sectoral investment

vector, A_i , and the column sums are equalled the investments by commodities, vector A_k .

Figure 5.2 Schematic Diagram of Vectors of Investment Goods and Investments by Industries



In Figure 5.2, A_{ik} represents total investment in 1983-84. To construct matrix A , we made a set of rules to allocate investment goods across industries. These rules are made because there are some investment goods that form capital in specific industries and can be mapped on a one to one basis. For example, agricultural machinery is used only in the agricultural industry. Similarly, there are some investment goods which, apparently, are not used to form capital in some of the industries, *e.g.*, auto-assembly parts are not used for the wholesale & trade industry. Finally there are some investment goods which can be used to form capital only in a subset of industries. For example, rural buildings can be used to form capital only in the agriculture, ownership of dwelling, government services, services-not-elsewhere-specified, wholesale & trade, and infrastructure industries. The use of the rural buildings in the agricultural industries represents all the construction work required for supply of water and storage of agricultural goods. In the ownership of dwelling industry it goes to the construction of residential buildings in the rural region. The government services, services-

not-elsewhere-specified, and infrastructure industries provide services of health, education, electricity distribution and community work. The buildings in these industries are treated as rural buildings. In line with these considerations we allocated investment goods between industries, as follows.

- (1) All sales of the agricultural machinery, plus 50 per cent sales of rural buildings, and 15 per cent sales of infrastructure were allocated to the agricultural industries.
- (2) All sales of factory building were assumed to form capital in the manufacturing industries, and were distributed between the small-scale and large-scale manufacturing industries in proportion to their shares in total investments of these industries. In addition it was assumed that no public building forms capital in the manufacturing industries.
- (3) All ship building and road investments were assumed to form capital in the transport industries. In addition, it was assumed that 70 per cent sales of the transport equipment were used for capital formation in the transport industries, while the remaining 30 per cent formed capital in other industries. We assumed that 2 per cent sales of public building were used for capital formation in transport industries.
- (4) All sales of low-cost residential building and luxury buildings were assumed to form capital in the ownership of dwelling industry. In addition, 15 per cent sales of rural building was also allocated to this industry. It was assumed that the non-electrical machinery good and the public building good are not used for capital formation in the ownership of dwelling industry.

Sales of all other investment goods were distributed between industries according to each industry's share in total investment, *i.e.*,

$$A_{ik} = \frac{A_{ik}}{A_{ik}} \times A_{ik}, \quad i \in \text{INVCOM}, k \in \text{SEC}. \quad (5.3.14.2)$$

These rules were applied for, both, domestic and imported investment goods. After the allocation of investment goods to industries, we applied the RAS procedure to balance the matrix.

To make the full matrix of 131 goods $\times$ 128 industries, we distributed purchases of investment goods by a group between its member industries using the following formula:

$$PUR2_{isj} = PUR2_{isk} \frac{VICAP_i}{VICAP_k}, \quad i \in INVCOM, s \in SRC, k \in SEC, j \in IND, (5.3.13.1)$$

where $VICAP_k$ is the aggregate capital income in industry group k . We assumed that usage of an investment good in an industry was in proportion to its share in total capital of its group. We mapped the investment goods from INVCOM to our set of 131 commodities from two sources.

5.3.14 Distribution of Returns to Fixed Factor into Land and Capital.

In the SAM, value added was distributed between labour and one fixed primary factor. The value-added of the fixed factor was an aggregation of returns to land and capital. We disaggregated these two components. We assumed that in the agricultural, mining and hydro-electricity industries, returns to land took a 60 per cent share in total rental value of fixed factor. The share was assumed to be 5 per cent for all other industries. These shares are in line with the assumption made in a study for Bangladesh (Salma, 1992).

5.3.15 Disaggregation of Corporate Capital and Land.

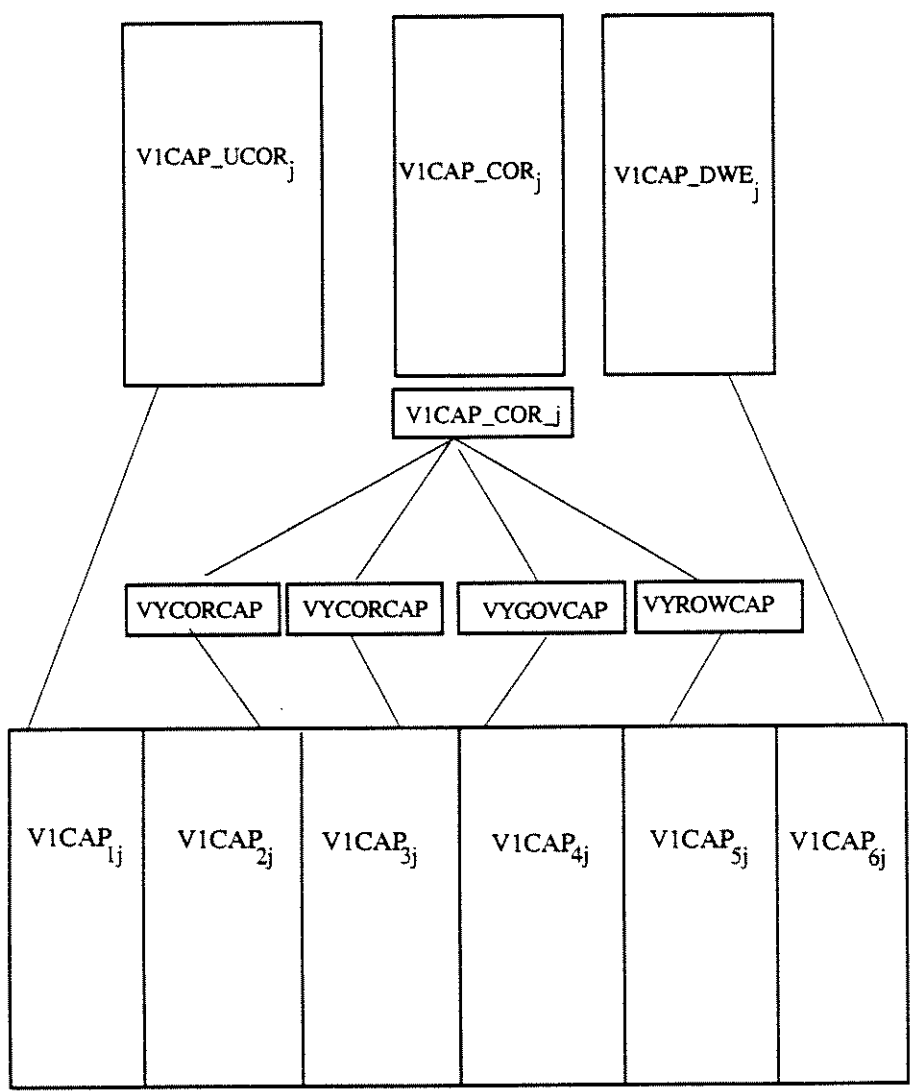
As shown in Figure 5.1, in the SAM the rental value of capital and land were attributed to three types of capital; non-corporate, corporate and dwelling capital. The rental value of corporate capital was again an aggregation of income from four sources; private corporations, public corporations, government and the ROW. The rental value of the four types of corporate capital is given in the income mapping matrices, (*i.e.* $VYCORCAP_0$, $VYGOVCAP$, and $VYROWCAP$) as

$$VICAP\_COR\_j = \sum_{o \in COR} VYCORCAP_o + VYGOVCAP + VYROWCAP. \quad (5.3.15.1)$$

As described below, we disaggregated corporate capital in industries into four types by distributing their rental values across industries using

supplementary data. Thus we constructed a matrix of value-added in industries by six types of capital, $VICAP_{cj}$, from the three vectors of value added of capital given in the SAM. Figure 5.3 below gives this mapping.

Figure 5.3 Schematic Diagram of Disaggregation of Corporate Capital



We transformed the 128×1 vector of corporate capital by industry into a matrix of 128×4 that shows four types of capital in each industry. We made this disaggregation in four steps.

- (1) Because no detailed data was available on employment of capital owned by the ROW at the industry level, we assumed that each industry followed the distribution pattern of total corporate capital. For

the first step, we distributed the capital rental to the ROW in proportion to the percentage share of each industry in total corporate capital,

$$VICAP_{5j} = VYROWCAP \times \frac{VICAP\_COR_j}{VICAP\_COR\_J}, \quad j \in IND. \quad (5.3.15.2)$$

- (2) In the second step we selected those industries in which corporate capital was solely owned by the government. In these industries a part of the capital was corporate capital but there were no private or public corporate capital in these industries. The nine industries are:

- low-cost residential building,
- luxurious residential building,
- rural building,
- public building,
- infrastructure,
- road transportation,
- rail transportation,
- roads, and
- government services.

We assumed government owned all the corporate capital in these industries, except for that part of each industry which was assumed to be owned by the ROW.

- (3) The government of Pakistan publishes detailed financial accounts of government sponsored corporations. A summary of the gross profit of these corporations in 1983-84 (GOP, 1985a) for major industries was used as supplementary data to allocate corporate capital to public corporation. We obtained public-corporate capital data from the supplementary data for the following industries:

- oil & gas,
- government services,
- banking & insurance,
- radio
- television,

- telephone, and
- air transportation.

At present there are two electricity utilities, one owned by the government, the other by a private corporation. Although the public utility is not a corporation, its budget has been separated from the government budget. Following the *Government Sponsored Corporation* statistics (GOP, 1985a), we allocated 75 per cent of corporate capital in the electricity industry to public corporate capital and 25 per cent to private corporate capital.

In the SAM, the ratio of private to public corporate capital was 52:48. We could have used this ratio to allocate corporate capital for all industries. However, according to statistics given in the *Economic Survey*, (GOP, 1989), the share of public corporate capital was higher in some industries such as cement, fertiliser, and electricity. Thus we distributed corporate capital into private and public ownership in the ratio of 50:50 in all industries except some selected industries for which this ratio is 45:55. In the cement industry the ratio is 25:75.

After allocating corporate-capital ownership using the supplementary industry level data, we made sure that

$$VICAP\_COR_j = VICAP_{2j} + VICAP_{3j} + VICAP_{4j} + VICAP_{5j}, \quad j \in IND, (5.13.5.3)$$

while

$$VYGOVCAP = \sum_{j \in IND} VICAP_{5j},$$

$$VYCORCAP_o = \sum_{j \in IND} VICAP_{3j}, \quad o = \text{private corporations},$$

$$VYCORCAP_o = \sum_{j \in IND} VICAP_{4j}, \quad o = \text{public corporations}.$$

The above procedure was also applied to split corporate land in industries into four types of land.

5.4 Sources of the Values Assigned to the Parameters of GE-PAK

All the elasticity parameters required to implement the model are listed in Table 4.2 in Chapter 4. Ideally, these elasticities should be estimated econometrically from cross sectional and time series data. However, given limited time and resources as well as data constraints, this was not possible for this study. Hence we decided to adopt plausible values from existing literature. A survey of the literature on Pakistan showed that information on these elasticities was scant. There are only a few studies on Pakistan that estimate some of the required parameters. This is the case for most of the developing countries (Vincent, 1986, p.11). The main purpose of this section is to explain the procedure of assembling elasticity parameters for the model.

5.4.1 The Elasticities of Substitutions between Primary Factors

Literature on estimates of elasticity of substitution between primary factors for many developed and developing countries is voluminous (Bandara, 1989). This literature suggests that time-series studies in most countries have produced sectoral estimates centred around 0.5. Almost all the studies which estimate these parameters for Pakistan have been carried out only for the manufacturing industries². Of these studies, only Khan (1989) has estimated a two-level nested CES function that allows substitution between capital and energy at the bottom level, and between labour and an energy-capital composite at the top level. Khan's estimated substitution elasticity between capital and energy was 0.175, while the elasticity of substitution between the energy-capital composite and labour was 0.48. Considering this information we assumed a set of values for elasticities of substitution between primary factors or primary factors and energy products; which is given in Table 5.5. General principles used to assemble these parameter values were as follows:

²Kazi, Khan and Khan (1976), Kazmi (1981), Kemal(1981), Battes and Malik (1987), Khan(1989) and Mahmood (1990).

- Substitution elasticities between primary factors, or between a commodity-factor composite and other factors, are always given values of 0.5.
- Substitution elasticities between capital and an energy product, or between capital and an energy-products-composite, are assumed to be 0.2. The choice of relatively low elasticity was influenced by this study's interest in short-run simulation.
- Substitution elasticities between fuels are relatively higher, even in the short run, as most of them (*e.g.*, natural gas and furnace oil) are close substitutes. We assumed a value of 0.5 for these parameters.
- Substitution elasticities between fuels and electricity are assumed to be relatively lower (we chose 0.2) because substitution in usage will require replacement of capital stock. The same is true for gasoline and high speed diesel substitution in the road transport industry.

Table 5.5 Elasticities of Substitution in Production Functions

Parameter	Value	Description of the Parameter
σ_{FAC}	0.5	Elasticity of substitution between primary factors.
σ_{AGR1}	0.2	Elasticity of substitution between fertiliser and land in the agricultural industries.
σ_{AGR2}	0.5	Elasticity of substitution between capital and high speed diesel in the agricultural industries.
σ_{AGR3}	0.5	Elasticity of substitution between the energy-capital composite, land, and labour in the agricultural industries.
σ_{AGR4}	0.2	Elasticity of substitution between light diesel oil and electricity in the agricultural industries.
σ_{IIND1}	0.5	Elasticity of substitution between fuels in the manufacturing, mining and construction industries.
σ_{IIND2}	0.2	Elasticity of substitution between composite fuels and electricity in the manufacturing, mining and construction industries.
σ_{IIND3}	0.2	Elasticity of substitution between energy-composite and capital in the manufacturing, mining and construction industries.
σ_{IIND4}	0.5	Elasticity of substitution between energy-capital composite, labour and land in the manufacturing, mining and construction industries.
σ_{IRDT1}	0.2	Elasticity of substitution between gasoline and high speed diesel in the road transport industry.
σ_{IRDT2}	0.2	Elasticity of substitution between gasoline-high-speed-diesel composite and capital in the road transport industry.
σ_{IRDT3}	0.5	Elasticity of substitution between fuel-capital composite, labour and land in the road Transport industry.
σ_{ISTM}	0.5	Elasticity of substitution between natural gas and furnace oil in the steam electricity industry.
σ_{ICCY}	0.5	Elasticity of substitution between natural gas and furnace oil in the combine cycle electricity industry.

5.4.2 Elasticities of Substitution between Domestic and Imported Commodities

No econometrically estimated values are available for elasticities of substitution between imported and domestic goods for Pakistan. Therefore, we drew plausible values for these elasticities from the literature on CGE models of other developing countries.

Table 5.6 Import-Substitution Elasticities in Selected CGE models of Developing Countries

Industry	Sri Lanka	Pakistan (Dhanani)	Columbia	Kenya	India	Turkey	Philippines
Agriculture	0.5-2.0	3.0	5.0	5.0	5.0	2.0	0.8-3.7
Mining	0.5	1.0	0.5	2.0	-	0.5	0.7-1.1
Food	1.0-2.0	1.0-1.5	3.1	4.0	-	0.65	0.1-4.1
Light-manufacturing	0.5	1.0	-	1.5	2.0	-	0.6
Heavy-manufacturing	0.5	1.0	-	0.5	0.5	0.50	0.2-5.0
Textiles	1.0	1.0	-	2.0	-	0.65	0.2-0.7
Petroleum	0.5	1.0	-	0.5	2.0	1.5	0.0
Services	2.0	1.0	2.0	3.0	3.0	0.20	0.0

Sources: Vincent (1986), Dhanani (1989), Clarete & Warr (1992), Bandara (1989).

In Table 5.6 the values given for Columbia, Turkey and the Philippines are based on empirical work. The parameter values for other countries have been set using 'best guess'. Since econometric estimates are not available for the Pakistan, we used best 'guess' values for the import-domestic substitution elasticities for various sectors in this study. The 'guesstimates' are based on the values of similar commodities given in Table 5.6 for other developing countries bearing in mind characteristics of imports to Pakistan.

In the SAM, agricultural, mining and large-scale manufacturing commodities are supplied from both domestic and imported sources. Heavy manufacturing goods such as machinery and equipment have the largest

import share. Most of the commodities in this category have more than 50 per cent import share. The main characteristic of this commodity group is that the domestic product is not a close substitute for the imported goods. Within some individual input-output commodity categories, domestic production is limited to a narrow range of products; other product varieties are imported. For example, although Pakistan produces a number of surgical instruments, it also imports a wide variety of sophisticated surgical apparatus and machinery. This suggests that not all imports of machinery items are closely substitutable for domestically produced goods. This argument can be extended for other imported commodities. Thus we assumed that the import-substitution elasticities are small and assigned a 0.50 value to these parameters for all imported goods. Further, we assumed that the elasticity of substitution between domestic and imported commodity i is the same for all users, *i.e.*, intermediate users, investors, government and item producers:

$$\sigma_{COM1j} = \sigma_{COM2j} = \sigma_{COM3j} = \sigma_{COM5j}$$

5.4.3 Household Expenditure Elasticities and the Frisch Parameter

Unlike other elasticity parameters, various studies estimated household expenditure and price elasticities in Pakistan³. The most recent and comprehensive work was done by Burney and Khan (1991). They estimated marginal expenditure shares and expenditure elasticities for urban and rural households in six income groups. Tables 5.7 and 5.8 give these expenditure elasticities. These estimates were made for twelve broad groups of consumption items using 1984-85 household level data. The estimates indicate that expenditure elasticities for different item groups vary with income. They also exhibit a cyclical pattern, which is explained in terms of quantitative as well as qualitative changes in the household consumption basket.

³Siddiqui (1982), Ali (1981, 1985), Burney and Akhtar (1990).

The main characteristics of the two sets of expenditure elasticities are summarised below.

- For the majority of items the overall elasticities for urban and rural households differ considerably. For example, housing, transport and communication, education, entertainment and miscellaneous items are technically luxury items for urban households, while for rural households, only entertainment and miscellaneous items are a luxury. Similarly, whereas the elasticities of food & drinks, household effects, health care, and durables are relatively higher for rural households, the opposite is true for clothing & footwear and education.
- According to the study, the difference between urban and rural expenditure elasticities is statistically significant for most of the items.
- For the majority of items the elasticities with respect to total expenditure vary widely across different income groups. Moreover, these differences between income groups follow different patterns for different items.
- The expenditure elasticities for fuel and lighting are, in general, higher for urban households than for rural. Expenditure on transport & communication includes gasoline consumption for private transportation. The expenditure elasticities for items in this group are also higher for urban households. These elasticities are highest for the high income group in both the regions.

Table 5.7 Expenditure Elasticities by Items and Income Groups for Rural Households

Item Groups & Item Numbers	Income Groups			
	Low	Middle	High	Others
Food & drinks (1-19)	0.85	0.74	0.46	0.79
Clothing & footwear (20-24)	0.75	0.70	0.50	0.68
Fuel & lighting (25-32)	0.57	0.43	0.31	0.63
Housing (33-36)	0.88	0.80	0.80	0.84
Transport & communication (49-50)	0.80	0.86	1.00	1.00
Household effects (37-42)	0.80	0.90	0.63	0.84
Personal effects (43)	0.91	0.92	0.58	0.97
Health care (44)	0.98	0.92	0.74	0.87
Education (45)	0.47	0.69	1.00	0.70
Entertainment (47)	1.00	0.84	1.00	0.98
Durable (46, 48)	0.91	0.75	1.00	0.87
Miscellaneous (51-53)	1.73	1.82	1.64	1.79

Source: Burney and Khan (1991).

Note: These elasticities' values are adjusted for the expenditure shares in PDB.

Table 5.8 Expenditure Elasticities by Items and Income Groups for Urban Households

Item Groups & Item Numbers	Income Groups			
	Low	Middle	High	Others
Food & drinks (1-19)	0.81	0.67	0.57	0.72
Clothing & footwear (20-24)	0.76	0.57	0.74	0.75
Fuel & lighting (25-32)	0.62	0.36	0.61	0.52
Housing (33-36)	1.0	1.00	1.00	1.19
Transport & communication (49-50)	1.00	1.00	1.68	1.51
Household effects (37-42)	0.73	0.57	0.79	0.76
Personal effects (43)	1.00	1.00	0.83	0.99
Health care (44)	0.83	0.83	0.88	0.77
Education (45)	1.00	1.00	1.00	1.25
Entertainment (47)	1.35	1.00	1.27	1.36
Durable (46,48)	0.50	0.79	1.63	0.87
Miscellaneous (51-53)	1.66	1.75	1.49	1.58

Source: Burney and Khan (1991).

Note: These elasticity values are adjusted for the expenditure shares in PDB.

Our model recognises three income groups (low, middle and high) in each region. We have mapped the estimates for income groups I, IV, and VI from the study to the three income groups in our data base. We assume the same set of elasticities for both employed and self-employed households. The seventh category of household in the two regions is residual, *i.e.*, 'other'. The study gives a set of expenditure elasticities for all types of household in a region. For the 'other' category of households we assume average elasticity values given in the study.

In GE-PAK specification we used average expenditure on items by household type from the data base and the corresponding expenditure elasticities to compute marginal expenditure shares for items by household type (see the equations in Block 8). Average expenditure shares are different for employed and self-employed households: so too are marginal expenditure shares.

The estimation of the Frisch parameter is mainly based on the study of Lluch *et al.* (1977). According to this study, the Frisch parameter rises from -7.5 to -2.0 as *per capita* income rises from US \$100 to US \$3000. Lluch approximates the relationship between *per capita* income in 1970 US \$(X) and the Frisch parameter ω by:

$$\omega = 36 X^{-0.36} \quad (5.4.3.1)$$

This relationship has been used to estimate the value of the Frisch parameter in several other CGE models⁴. The estimated values for the Frisch parameter for selected developing countries are listed in Table 5.9.

Table 5.9 Values for the Frisch
Parameter in Selected CGE Models

Country	Value
Chile	-2.525
India	-6.500
Ivory Coast	-3.706
Kenya	-6.000
Turkey	-5.160
South Korea	-3.700

Source: Vincent (1986).

Bandara (1989) estimated the Frisch parameter for a CGE model of Sri Lanka. His estimates for the urban and rural households are -4.57 and -5.45 respectively.

Using equation (5.4.3.1) we computed a set of Frisch parameters from *per capita* income data. Ahmad and Ludlow (1988) computed *per capita* income and expenditure series from the *Household Income and Expenditure Survey* (GOP, 1983 and 1986). In this data set *per capita* income and expenditure of households are given for 20 income groups of urban and rural

⁴ For example Dervis, de Melo and Robinson (1982) and Vincent (1986).

households. The households are grouped by *per capita* income (expenditure) at 5 per cent interval. The first group represents average *per capita* income (expenditure) of the 5 per cent of households with the lowest income while the last group represents average income of the 5 per cent of households with the highest income. The same survey data was used by Burney and Khan (1991) to estimate the expenditure elasticities discussed in this section. Burney and Khan distributed households into seven income groups. We selected the *per capita* income values for urban and rural households by mapping the percentage of households covered by our three income-groups; low, middle and high. Our computed values for the Frisch parameters are given in Table 5.10. We assumed that the *per capita* income of self-employed and employed groups are the same. For rural and urban households in the 'others' categories, we computed the Frisch parameters using the average *per capita* income of the two regions.

Table 5.10 Computed Values of Frisch Parameter for Pakistan

Household Category	Frisch-Parameter Values	
	Rural	Urban
Low-Income	-5.90	-5.93
Middle-Income	-4.74	-4.54
High-Income	-2.82	-2.62
Others	-4.62	-4.07

5.4.4 Demand Elasticities of Exports

In most CGE models of developing countries, the small country assumption is made with respect to world prices (for most commodities) being insensitive to that country's export volumes. Accordingly, it is assumed that, except for few commodities, the world prices are insensitive to export volumes as the market shares of these exports are insignificant. Hence, export demand elasticities are assumed to be high for most commodities. For example Bandara (1989) assumed a value of -20.0 for all the export commodities except for tea (-1.20). Similarly in a CGE model for India, export

elasticities for all the commodities are assumed to be -20.0 except for tea and Jute (see Vincent, 1986). In the absence of any empirical evidence we assumed that all export commodities of Pakistan have an insignificant share in the world market. Hence we assumed an export elasticity of -20.0 for major exports in line with the values assumed for other developing countries (see the short-run closure in Chapter 6 for treatment of the remaining exports).

5.4.5 Investment Parameters

The standard investment theory in our model is drawn from ORANI. It rests on the equalisation of expected rates of return in industries to some rate, r_{tot} , which will satisfy the aggregate investment constraint (see equations in Block 21). It is necessary to specify values for three parameters.

- The elasticity of expected rate of return on capital in industry j with respect to an increase in planned capital stock in that industry ($BETA\_R_j$).
- The ratio of industry j 's gross investment to future capital stock (INV_ELAST_j).
- The ratio of the gross to the net rate of return ($QCOEF_j$).

In a standard short-run closure the model redistributes exogenously given aggregate investment across industries (see Section 4.29 in Chapter 4 for an elaboration of this mechanism).

However, the short-run simulations performed in this study assume that investment in each industry is given exogenously and the capital stock in each industry is fixed. Hence, two of the parameters, $BETA\_R_j$ and INV_ELAST_j , have no role to play⁵. The parameter $QCOEF_j$ is still required to determine rates of return in industries.

⁵ In Table 5.9 we have given arbitrary values to these parameter to complete the list. To implement the model for alternative investment closure, see Bandara (1989) for 'best guess' values of $BETA\_R_j$ and INV_ELAST_j . Bandara (1989) used these values to implement his CGE model of Sri Lanka.

To implement the model we assumed a uniform value of 2.0 for $QCOEF_j$. The assumed value has no effects on results except for the rates of returns $r0_j$.

5.4.6 Elasticities of Substitution between Different Types of Labour

Four categories of labour are identified in the model on the basis of two regions (urban and rural) and two professions (skilled and unskilled). All the industries use labour from both regions except agricultural and large-scale manufacturing industries. Agricultural industries use only rural labour while large-scale manufacturing industries use only urban labour. We assumed a Leontief production function for labour from two regions in all industries while labour demand from a region is a CES composite of two types of profession; skilled and unskilled. No estimates are available for the elasticity of substitution between skilled and unskilled labour for Pakistan. Ahmed (1981)⁶ estimated a production function and input elasticities in the construction of low-cost housing in six cities in developing countries. In the study, elasticities of substitution between capital and labour and between skilled and unskilled labour are estimated by CES production functions. The study concludes that, in general, both the elasticities are quite low. In Ahmed's study, the estimated substitution elasticity between skilled and unskilled labour is 0.66. To implement our model we chose a value of 0.5 for the substitution elasticity between skilled and unskilled labour; for both urban and rural regions. Hence we assume

$$\sigma_{PRF_{ij}} = 0.5, \quad j \in IND, r \in REG.$$

⁶ Ahmed (1981) made a survey of low-cost housing industries in Rawalpindi (Pakistan), Colombo (Sri Lanka), Tunis (Tunisia), Nairobi (Kenya), Lusaka (Zambia), and Medellin (Colombia). In addition to other problems, the sample size of the survey is very small (35 observations).

5.4.7 All Other Parameters of the Model

In this section we discuss all the parameters of the model for which no reference values are available from other studies. To implement our model we use 'best guess' values for these parameters.

These parameters include the elasticity of substitution between electricity supply from less-flexible and more-flexible electricity industry groups (σ_{IELE}), and between the electricity industries within each group (σ_{IELEL} and σ_{IELEM}). We assumed a low value (0.2) for substitution between low and more-flexible electricity and assumed a higher value of substitution, (0.5) for electricity supply from different industries within less-flexible and more-flexible electricity industry groups.

Elasticity of household migration (σ_{REG_p}) is another parameter set for which no estimated values are available. We assumed a value of 0.5 for migration of both skilled and unskilled groups.

In our data base, only the refinery industry has multiple outputs. Hence, the output transformation elasticity, σ_{OUT} , is relevant only for transformation possibilities for petroleum products. In the short run, it seems appropriate to assume a low value (0.2) for the refinery industry.

5.4.8 A Complete List of Parameters of the Model

For a ready reference we have listed values of all the model parameters (except expenditure elasticities and import substitution elasticities) in Table 5.11. The parameters appear in alphabetical order. To complete the list, we report the values for $BETA_{R_j}$ and INV_ELAST_j parameters which are generally used in the short-run applications of ORANI.

Table 5.11 Parameters of the Model

Parameter	Value	Description
BETA_R _j	5.0	Elasticity of expected rate of return on capital in industry j with respect to an increase in planned stock of capital in that industry.
EXP_ELAST _i	-20.0	Export demand elasticities.
INV_ELAST _j	0.50	The ratio of industry j's gross investment to its future capital stock.
QCOEF _j	2.0	Ratio of gross to net rate of return.
σAGR1	0.20	Elasticity of substitution between fertiliser and land in the agricultural industries.
σAGR2	0.50	Elasticity of substitution between capital and high speed diesel in the agricultural industries.
σAGR3	0.50	Elasticity of substitution between energy-capital composite, land, and labour in the agricultural industries.
σAGR4	0.20	Elasticity of substitution between light diesel oil and electricity in the agricultural industries.
σCOM1 to σCOM3 and σCOM5	0.50	Elasticity of substitution between domestic and imported goods for 4 consumer groups.
σFAC	0.50	Elasticity of substitution between primary factors.
ICCY	0.50	Elasticity of substitution between natural gas and furnace oil in combined cycle industry.
σIELE	0.50	Elasticity of substitution between less-flexible and more-flexible electricity.
σIELEM	0.70	Elasticity of substitution between two types of more-flexible electricity (hydro and gas turbine electricity).
σIELEL	0.30	Elasticity of substitution between two types of less-flexible Electricity (Steam and combined cycle electricity).
σIIND1	0.50	Elasticity of substitution between fuels in the manufacturing, mining and construction industries.

... continued

Table 5.11 (continued)

Parameter	Value	Description
σ_{IIND2}	0.20	Elasticity of substitution between composite fuels and electricity in the manufacturing, mining and construction industries.
σ_{IIND3}	0.20	Elasticity of substitution between composite energy and capital in the manufacturing, mining and construction industries.
σ_{IRDT1}	0.20	Elasticity of substitution between gasoline and high speed diesel in the road transport industry.
σ_{IRDT2}	0.20	Elasticity of substitution between fuel-composite and capital in the road transport industry.
σ_{IRDT3}	0.50	Elasticity of substitution between fuel-capital composite , labour and land in the road transport industry.
σ_{ISTM}	0.50	Elasticity of substitution between natural gas and furnace oil in steam electricity industry.
σ_{OUT_j}	0.20	Elasticity of transformation in industry $j \in \text{NONIELE}$.
σ_{OUT_j}	0.0	Elasticity of transformation in industry $j \in \text{IELE}$.
$\sigma_{PRF_{rj}}$	0.5	Elasticity of substitution between skilled and unskilled labour by region and industry.
σ_{REG_p}	0.50	Elasticity of migration for profession p .

Chapter 6

Application of GE-PAK for Evaluation of Energy Pricing Policy in Pakistan

6.1 Introduction

In this chapter we apply GE-PAK to evaluate energy pricing policy in Pakistan. We made twenty-one simulations which assume hypothetical reforms in energy prices. Table 6.1 contains the names of these simulations with a brief description of each. We simulate the general-equilibrium effects of these hypothetical reforms. The objective of this chapter is to discuss these simulation results. Our review of the prices of energy products (petroleum products, electricity and natural gas) suggests that there are three types of major distortions in these prices.

- (A) There is source-discrimination in taxes on petroleum products in the form of import taxes and subsidies *i.e.* imported and domestic varieties of the same good are taxed differently.
- (B) There is product-discrimination in taxes on petroleum products. Sales tax rates on different products are not uniform: for example the tax on high speed diesel is different from that on furnace oil.
- (C) There is user-discrimination in taxes on electricity and natural gas. The implicit tax rates on these products are not uniform among major consumer categories.

There are many ways to set up experiments to compute the effects of removing various distortions in energy pricing. In this application we choose eight experiments to show the capability of the model to provide detailed information which are useful in analysis of energy policy issues. The eight experiments are as follows.

- (1) In the first experiment we eliminate source-discriminating taxes on petroleum products. Simulations SIM1a to SIM1d show the effects of

removing import taxes (subsidies) on four petroleum products. Subsections 6.3.1 to 6.3.3 present the results of these simulations and discuss the mechanism through which a change in the price of each petroleum product produces the reported results. The cumulative effects of removing all source-discriminating taxes on petroleum products are simulated in SIM1. Subsection 6.3.4 discusses SIM1 results.

Table 6.1 List of Simulations

Simulation Name	Description	Revenue Neutral
SIM1a	Elimination of source-discriminating tax (import tax) on high speed diesel.	No
SIM1b	Elimination of source-discriminating tax (import tax) on gasoline.	No
SIM1c	Elimination of source-discriminating tax (import subsidy) on kerosene.	No
SIM1d	Elimination of source-discriminating tax (import subsidy) on furnace oil.	No
SIM1	Elimination of all source-discriminating taxes on petroleum products (SIM1a + SIM1b + SIM1c + SIM1d).	No
SIM2	Elimination of all product-discriminating explicit sales taxes on petroleum products.	No
SIM3	Elimination of all source- and product-discriminating explicit sales taxes on petroleum products (SIM1 + SIM2).	No
SIM3N	Elimination of all source- and product-discriminating explicit sales taxes on petroleum products (SIM3 + Revenue- neutralising taxes).	Yes
SIM4a	Elimination of user-discriminating tax (subsidy) on electricity sales to agricultural industries.	No
SIM4b	Elimination of user-discriminating tax (subsidy) on electricity sales to households.	No
SIM4c	Elimination of user-discriminating tax on electricity sales to large-scale manufacturing industries.	No

....continued

Table 6.1 (continued)

Simulation Name	Description	Revenue Neutral
SIM4d	Elimination of user-discriminating tax on electricity sales to small-scale manufacturing industries.	No
SIM4e	Elimination of user-discriminating tax on electricity sales to services industries.	No
SIM4	Elimination of all user-discriminating taxes on electricity (SIM4a + ...+SIM4e).	No
SIM4N	Elimination of all user-discriminating taxes on electricity (SIM4 + Revenue-neutralising taxes).	Yes
SIM5a	Elimination of user-discriminating tax on natural gas sales to households.	No
SIM5b	Elimination of user-discriminating tax on natural gas sales to all manufacturing industries.	No
SIM5c	Elimination of user-discriminating tax on natural gas sales to services industries.	No
SIM5d	Elimination of user-discriminating tax (subsidy) on natural gas sales to electricity industries.	No
SIM5	Elimination of all user-discriminating taxes on natural gas (SIM5a + ...SIM5d).	No
SIM5N	Elimination of all user-discriminating taxes on natural gas (SIM5 + Revenue-neutralising taxes).	Yes
SIM6	One per cent change in the power of tax on all commodities. Results are retained for each shock individually.	No

- (2) In the second experiment we eliminate all product-discriminating explicit sales taxes on petroleum products by making the sales tax rate on each product equal to the average tax rate on all petroleum products. Simulation SIM2 shows the results of this experiment. In Section 6.4 we discuss these results.

- (3) In the third experiment we eliminate all source- and product-discriminating taxes on petroleum products. Simulation SIM3 shows the results of this experiment; these results give the total of effects in SIM1 and SIM2. Section 6.5 discusses these cumulative effects of removing both source- and product-discriminating taxes.
- (4) In the fourth experiment we eliminate both the source- and product-discriminating taxes on petroleum products in a revenue-neutral environment. In this experiment we impose a uniform percentage change in tax rates on all other commodities such that total indirect tax revenue remains unchanged. SIM3N shows the cumulative effects of SIM3 with a revenue-neutrality condition. Section 6.6 presents these results.
- (5) In the fifth experiment we eliminate user-discriminating taxes on electricity sales by making the tax rates on sales to five major consumer categories uniform and equal to the average tax rate on electricity. Simulations SIM4a to SIM4e show the effects of removing user-discriminating taxes on five major consumer categories. Subsections 6.7.1 to 6.7.5 discuss the results of SIM4a to SIM4e. As shown in Table 6.1, simulation SIM4 shows the cumulative effects of removing all user-discriminating taxes on electricity. Subsection 6.7.6 discusses SIM4 results.
- (6) In the sixth experiment we eliminate user-discriminating taxes on electricity sales in a revenue-neutral closure. The results of SIM4N show the cumulative effects of the reforms in electricity prices along with a uniform change in tax rates on all commodities. Hence, SIM4N results show SIM4 results plus the effects of revenue-neutralising taxes. Section 6.8 presents these results.
- (7) In the seventh experiment we remove user-discriminating taxes on natural gas sales to four major consumer categories. We make the implicit tax rates on all consumer categories uniform and equal to the average tax rate on natural gas. Simulations SIM5a to SIM5d show the effects of the changes in the tax rates for four consumer categories. Subsections 6.9.1 to 6.9.4 present these simulation results. In simulation SIM5 we compute the

cumulative effects of removing all user-discriminating taxes on natural gas. Subsection 6.9.5 discusses these cumulative effects.

- (8) In the eighth experiment we remove all user-discriminating taxes on natural gas in a revenue-neutral environment. Simulation SIM5N shows the cumulative effects of the changes in tax rates on all commodities in this experiment. Hence, the results of SIM5N show results of SIM5 plus the effects of revenue-neutralising taxes. Section 6.10 discusses these results.

The aim of these experiments is to analyse how far these discriminating taxes meet the announced objectives of energy pricing policy in Pakistan. Our analysis of these results focuses on the effects on equity of removing these distortions along with the macro and micro economic effects of these reforms. We also compute the social welfare cost of revenue generation from indirect taxes on energy products. To do this we simulate a 1 per cent increase in the tax rate on seven energy products individually. We then compute a set of the elasticities of social welfare cost of government revenues (SWC) for all them. The social welfare costs are computed for two values of the Atkinson equity parameter (1970). We use these elasticities to rank the energy products according to their social welfare cost. Section 6.11 reports the two rankings and their analysis. Our analysis focuses on two aspects:

- Which energy products have higher social welfare cost per dollar of tax revenue?
- How much does the ranking of energy products change with the change in value of the equity parameter?

As discussed in Chapters 2 and 4, the prices of major commercial energy products are regulated by the government. In all the twenty-one simulations we assume that the implicit tax rates on these products are exogenous and all prices are determined endogenously. Thus with reference to equation (4.15) in Section 4.24 of Chapter 4, the model projects shifts in prices of energy products that have regulated prices.

In Section 6.2 we discuss the closure of our model for the above mentioned simulations. We report the results of the simulations in Sections 6.3 to 6.11.

The simulation results of GE-PAK contain detailed information on the effects of an exogenous shock. This includes all endogenously determined macro variables and commodity-, industry- and household-level micro variables determined endogenously (see Table 4.2 for the list of endogenous variables). These detailed results help us to understand the mechanism through which an exogenous shock effects the economy. However, it is not possible to report all these endogenously-determined variables. To evaluate the effects of the reforms in energy price we focus on variables concerning the four major objectives of energy pricing policy in Pakistan:

- equity or distributional effects;
- the balance of trade;
- indirect tax revenues; and
- economic growth in total, and by sector.

Thus for each simulation, we are mainly interested in real GDP, the balance of trade, total real consumption, real consumption of households by income group and region, and sectoral output. In our analysis of equity, we focus on the pattern of changes in real consumption of households by income group and region instead of a single income inequality index. Total real consumption is a simple weighted-average over all types of household; this represents effects on household consumption without distributional concern. In the model there are 128 industries producing 131 commodities. To report the effects of energy price reforms on sectoral growth composition we have aggregated changes in the production level of these industries into ten groups:

- agriculture;
- oil & gas;
- large-scale manufacturing including other mining industries, and excluding energy producing and energy intensive industries;
- small-scale manufacturing;

- services;
- fertiliser;
- refinery;
- cement;
- natural gas; and
- electricity.

In Appendix E, Table E1 lists the name of industries in each sector.

There is an interaction of various factors which determine the effects of a policy shock. In presentation of our results, we reveal each part of the mechanism as we proceed.

- As shown in Table 6.1, all shocks to the tax rates are first given without a revenue-neutrality condition. Thus any change in a tax rate reallocates income from the public budget to private consumption or *vice versa*. Hence results in these simulations are the combined effects of change in the tax on an energy product and the effects of change in private consumption. We disaggregate the two effects and discuss them at length for SIM1a results (see Section 6.3.1). For the remaining simulations, we only discuss the effects on aggregate.

- Similarly, the effects on real *per capita* consumption for 14 types of household are determined through changes in their nominal income, CPI and changes in number of households in a household group. We discuss this mechanism in detail for SIM1 (see Section 6.3.4). For all other simulations we report changes in real *per capita* consumption without going into great detail.

- An important part of our analysis is discussion of distributional effects of a policy shock. We analyse these effects by comparing changes in real *per capita* consumption of 14 types of household. The households are grouped by region, employment category and income groups (see Figure 4.2 in Chapter 4). There are several ways to make the comparisons:

(a) Across region for income groups in an employment category

For example, real *per capita* consumption of three rural-income groups are compared with real *per capita* consumption for their counter parts in the

urban region in the employed category. Thus comparison is made between rural-low-income-employed and urban-low-income-employed group. Similarly the same comparison is made for the self-employed category.

(b) Across income-groups in a region for an employment category

For example, real *per capita* consumption for the low-income group is compared with real *per capita* consumption for middle- and high-income groups in the rural region for the self-employed category. A similar comparison can be made for rural-employed category, urban-self-employed category and urban-employed category.

(c) Across employment categories in a region and income group

For example, real *per capita* consumption of rural-low-income group in self-employed category is compared with real *per capita* consumption for rural-low-income in the employed category. A similar comparison can be made for other income groups.

It is not possible for us to make all these comparisons. Therefore, we focus on the differences which stand out in a simulation result, and explain these differences. Thus in some simulations we discuss in more detail inter-region differences while in others we compare income groups.

6.2 Macroeconomic Environment: A Short-run Closure

The choice of exogenous variables, together with the values prescribed for them, and the values of user-specified parameters, determine the economic environment assumed for the experiment. Table 6.2 lists selected exogenous variables for all the 21 simulations discussed in Sections 6.3 to 6.11. In all the simulations we assume that there is no change in these variables except in the powers of import taxes and sales taxes on energy products. The important assumptions about the macroeconomic environment in our simulations are as follows:

- industry-specific capital stocks are fixed;
- real government spending and real investment by industries are fixed;

- supplies of labour from households by profession and income groups are fixed but regional wage difference may cause labour migration.
- the average propensity to consume for each of the 14 types of household is fixed;
- the number of households by profession is fixed;
- the nominal exchange rate is fixed and acts as the numeraire and;
- all the regulated prices are also determined endogenously.

In the following few paragraphs we discuss our major assumptions in more detail.

Our assumption of fixed capital stocks implies that we are looking at the effects of changes in energy prices after a period which is sufficiently short that we can ignore induced changes (from the levels they otherwise would have reached) in industry capital stocks available for use in production. The assumption of exogenous investment in each industry has two justifications. First, in Pakistan the government makes investment plans at the outset of its five-year economic plan. Along with the investment projects in the public sector, the government sets some expected targets for private investment in major sectors of the economy. Second, the credit policy, made by the government, is also set in line with the allocation of expected private investment among major sectors. Our assumption is that in the short run the credit policy and investment plan are not affected by the changes in energy prices.

Concerning the labour market, real wages of labour are determined endogenously as the labour supply by profession is fixed. However, the labour supply function in a region is upward sloping due to inter-region migration function which allows mobility of each profession type between the two regions.

Table 6.2 List of Exogenous Variables

Exogenous Variable	Subscript Range	Number	Description
f5tot	1	1	Shift in aggregate consumption of government.
phi	1	1	Exchange rate; Rs per \$US.
t0 [†]	1	1	Uniform % change in the power of sales tax on all commodities and all usage.
t1_isj	1	1	Uniform % change in the power of sales tax on intermediate usage.
t2_isj	1	1	Uniform % change in the power of sales tax on all commodities for capital formation.
t3_is	1	1	Uniform % change in the power of sales tax on all commodities for item formation.
t5_is	1	1	Uniform % change in the power of domestic tax on all commodities for government consumption.
rtot	1	1	Average rate of return on aggregate investment.
fep _i	$i \in \text{COM}$	131	Price (upward) shift in the export demand schedule for commodity i .
feq _i	$i \in \text{COM}$	131	Quantity (right) shift in export demand schedule for commodity i .
pmi _i	$i \in \text{COM}$	131	Foreign currency import price of commodity i .
t4 _i	$i \in \text{COM1}^{\dagger\dagger}$	13	Power of tax on exports of commodity i .
x4 _i	$i \in \text{COM2}^{\dagger\dagger}$	118	Export quantity of commodity i .

[†] This variable is swapped with total indirect tax revenue variable in simulations with revenue-neutrality condition. ^{††}COM1 and COM2 are two subsets of COM. See Table 6.3 for commodities in COM1; COM2 is the complement of COM1.

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Table 6.2 (continued)

Exogenous Variable	Subscript Range	Number	Description
tm_i	$i \in \text{COM}$	131	The power of import tax on commodity i.
$a1_{sij}$	$i \in \text{COM}$ $j \in \text{IND}$	131×128	Input-i augmenting technical change in current production in industry j.
$a2_{sij}$	$i \in \text{COM}$ $j \in \text{IND}$	131×128	Input-i augmenting technical change in capital formation.
$t1_{eij}$	$i \in \text{COM}$ $j \in \text{IND}$	131×128	Uniform % change in power of ax on commodity i for intermediate usage in industry j.
$t2_{eij}$	$i \in \text{COM}$ $j \in \text{IND}$	131×128	Uniform % change in the power of tax on commodity i for capital creation in industry j.
$t3_{ei}$	$i \in \text{COM}$	131	Uniform % change in power of import and sales taxes on commodity i for item formation.
$a4mar_{im}$	$i \in \text{COM}$ $m \in \text{MAR}$	131×3	Margin-good m augmenting technical change for export of commodity i.
$f5_{is,}$	$i \in \text{COM}$ $s \in \text{SRC}$	131×2	Shift in government demand for commodity i from source s.
t_{is}	$i \in \text{COM}$ $s \in \text{SRC}$	131×2	The power of indirect tax on commodity i from source s.
$a1_{isj}$	$i \in \text{COM}$ $s \in \text{SRC}$ $j \in \text{IND}$	131×2 $\times 128$	Source-specific input i augmenting technical change in current production in industry j.
$a2_{isj}$	$i \in \text{COM}$ $s \in \text{SRC}$ $j \in \text{IND}$	131×2 $\times 128$	Source-specific input i augmenting technical change in capital formation in industry j.

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Table 6.2 (continued)

Exogenous Variable	Subscript Range	Number	Description
a1mar _{isjm}	$i \in \text{COM}$ $s \in \text{SRC}$ $j \in \text{IND}$ $m \in \text{MAR}$	$131 \times 2 \times$ 128×3	Margin-good m augmenting technical change on supply of commodity i to industry j from source s for current production.
a2mar _{isjm}	$i \in \text{COM}$ $s \in \text{SRC}$ $j \in \text{IND}$ $m \in \text{MAR}$	$131 \times 2 \times$ 128×3	Margin-good m augmenting technical change for commodity i supply to industry j from source s for capital formation.
a3mar _{ism}	$i \in \text{COM}$ $s \in \text{SRC}$ $m \in \text{MAR}$	131×2 $\times 3$	Margin-good m augmenting technical change for commodity i supply to industry j from source s for item formation.
a5mar _{ism}	$i \in \text{COM}$ $s \in \text{SRC}$ $m \in \text{MAR}$	131×2 $\times 3$	Margin-good m augmenting technical change for commodity i supply from source s for government consumption.
tycor _o	$o \in \text{COR}$	2	Corporate-income tax.
drate _o	$o \in \text{COR}$	2	Dividend rate of corporations.
atot _j	$j \in \text{IND}$	128	Hicks-neutral change across all inputs in industries.
alcap _{cj}	$j \in \text{IND}$	128	Technical change in capital-use in industries.
allab _{rpj}	$j \in \text{IND}$	128	Technical change in labour-use in industries.
allnd _{dj}	$j \in \text{IND}$	128	Technical change in land-use in industries.
aloct _j	$j \in \text{IND}$	128	Technical change in other costs in industries.
a2 _{isj}	$j \in \text{IND}$	128	Hicks-neutral change across all inputs for capital formation.
alprm _j	$j \in \text{IND}$	128	Technical change in primary factors use in industries.

.... continued

Table 6.2 (continued)

Exogenous Variable	Subscript Range	Number	Description
$x1lnd\_dj$	$j \in IND$	128	Current land stock in industry j .
$x1cap\_cj$	$j \in IND$	128	Current capital stock in industry j .
y_j	$j \in IND$	128	Real investment in industry j .
$aitem_{km}$	$k \in ITM$ $r \in REG$ $n \in INC$	53×2 $\times 7$	Exogenous shift in taste of households from region r and income-group n for item k .
q_rnp	$n \in INC$ $p \in PRF$	7×2	Number of households in income group n with profession p .
$hsize_m$	$r \in REG$ $n \in INC$	2×7	Number of persons per household in region r and income-group n .
$fyhou\_gov_m$	$r \in REG$ $n \in INC$	2×7	Exogenous shift in transfers from government to households.
$fyhou\_row_m$	$r \in REG$ $n \in INC$	2×7	Exogenous shift in transfers from the rest of the world to households.
$thou_m$	$r \in REG$ $n \in INC$	2×7	Exogenous shift in income tax for households.
apc_m	$r \in REG$ $n \in INC$	2×7	Average propensity to consume in households from region r and income group n .
$allab\_prj$	$r \in REG$ $j \in IND$	2×128	Technical change in use of region-specific labour in industries.
$unemp_{rp}$	$r \in REG$ $p \in PRF$	2×2	Shift in labour supplies from households, in region r , of profession type p .
$allab_{rpj}$	$r \in REG$ $p \in PRF$	2×2	Technical change in use of region-profession-specific labour in industries.
$fyhouhou_{rmn}$	$r \in REG$ $n \in INC$	2×7 $\times 2 \times 7$	Shift in inter-household transfers.

We assume that the average propensity to consume for each household type is constant in the short run and its expenditure is determined endogenously. Hence, in these simulations, any change in the energy prices affects household consumption directly through changes in consumer prices and indirectly through changes in their income. We assume that any change in the cost of living of households or in their income affects their savings and consumption level.

Export quantities are held fixed at the base year level for all but 13 commodities. For these 13 commodities more than 25 per cent of their total sales in the base year are exported. We assume that the export demand curves for these commodities are downward sloping and their export quantities are determined endogenously while the export taxes on these commodities are exogenously given. Table 6.3 lists the endogenous export commodities names and the export shares in their base-year sales. These commodities form 60 per cent of total exports in the base year. For the remaining commodities, export quantities are given exogenously and export taxes are determined endogenously.

Consistent with the short-run focus, technological parameters, household preferences, industry-specific land stocks, direct tax rates, the number of households by profession, and number of persons per household in each household type are assumed to be unaffected by the changes in energy prices. All these variables are exogenous and have a value of zero change in the simulations. The various types of indirect tax rate are exogenous with zero change except for energy products. The taxes on energy products are exogenous and are given policy shocks. We discuss the assumed values of changes in the power of indirect taxes on these products for each simulation before presenting the simulation results. In all simulations, we assume that all the regulated prices are determined endogenously. For example when we give a policy shock to the tax on a petroleum product, prices of all the commodities with regulated prices (such as the remaining petroleum products, electricity, natural gas) do not remain fixed but change at the margin according to the market conditions.

Table 6.3 Major Exports of Pakistan and their Shares in their Base-Year Sales

Commodity Names	(1) Commodity No. [†]	(2) Share Exported ^{††}
Carpets and rugs	36	0.81
Cotton fabrics	31	0.65
Wearing apparels	39	0.64
Fish and fish products	25	0.46
Sports goods	73	0.45
Small-scale rice (husked)	77	0.41
Rice (milled)	21	0.39
Leather and leather products	43	0.36
Silk and synthetics	32	0.33
Other textiles	37	0.32
Surgical instruments	74	0.31
Air transportation	119	0.26
Thread ball making	35	0.25

[†] Commodity number in set of commodities COM1.

^{††} Basic value of exports as a proportion of the basic value of total output.

6.3 The Effects of Removing Source-discriminating Taxes on Petroleum Products

In this section we present the results of the first experiment in which we remove the import taxes (subsidies) on the four petroleum products. To carry out this experiment we first compute the required changes in the power of import taxes on these products. The power of a tax is one plus the *ad valorem* tax rate. If there is a subsidy then the power of the tax is less than one. The power of the tax equals one if there is no tax. Table 6.4 shows the power of import taxes on petroleum products in the base year and the corresponding required changes in them which set the import tax rates on petroleum products to zero level. For example in the base year, the power of the import tax on kerosene was 0.83. We increase it by 20 per cent to offset the subsidy on kerosene ($1.2 \times 0.83 = 1$). As

detailed in Section 5.3.10, the GE-PAK database has been framed so that import tax rates show the difference in the rate of indirect taxation between domestic and imported variants of each product. In these shocks, we only remove the difference in the import and sales tax rates. For example there is no sales tax on kerosene whether imported or domestically produced but there is a subsidy on its import. In this experiment we remove this difference in the two taxes.

Table 6.4 Values for the Exogenous Power of Import Taxes on Petroleum Products

Petroleum Products	(1) Power of Import Tax in the Base Year	(2) Percentage Change in Power of Import Tax†
High speed diesel	1.06	-6.0
Gasoline	1.56	-36.0
Kerosene	0.83	20.0
Furnace oil	0.46	85.0

† These shocks are given to the power of imports taxes in SIM1a- SIM1d, SIM1, SIM3 and SIM3N.

As shown in column 2 of Table 6.4, we reduce the powers of the import taxes on high speed diesel and gasoline and increase them on kerosene and furnace oil to eliminate source-discriminating taxes on petroleum products.

In Table 6.7 columns 1 to 4 contain the effects on selected endogenous variables in SIM1a to SIM1d. The last column in this table contains the cumulative effects of these four shocks (SIM1). In the following paragraphs we highlight the effects generated by the change in a petroleum product price in each simulation and the mechanism that produces these results.

Subsections 6.3.1 and 6.3.2 cover the effects of eliminating import tax on high speed diesel (SIM1a) and gasoline (SIM1b) respectively. Subsection 6.3.3 covers the effects of eliminating import subsidies from kerosene (SIM1c) and furnace oil (SIM1d) while subsection 6.3.4 discusses the total impact of all these changes (SIM1).

6.3.1 The Effects of Eliminating the Import Tax on High Speed Diesel-SIM1a

In this section we discuss the results of removing the source-discriminating tax on high-speed diesel (SIM1a) reported in column 3 of Table 6.5. In our short-run closure, we assume that average propensity to consume in the 14 types of household is given exogenously and is held fixed in all simulations. Since all other tax rates (direct or indirect) are exogenously fixed, the changes in the import taxes on petroleum products reallocate income from the public budget to private consumption or *vice versa*. Hence our results are the combined effects of changes in the tax on petroleum products and the effects of the change in private consumption. For SIM1a, we analyse these two effects separately to understand their combined net effects. To disaggregate the two effects, we repeat SIM1a shock but assume that real consumption for each household group is fixed (we refer this as Case 1 of SIM1a). These results are reported in column 1 of Table 6.5. Results of Case 1 give us decreases in average propensities to consume for 14 types of household which keep the real consumption of household fixed when there is a change in their incomes. Conversely these decreases in average propensities to consume show us the changes in real consumption of household when import tax on high speed diesel is removed. In Case 2 of SIM1a, we increase the real consumption of household by the same extent but without removing the tax on high speed diesel. These results are reported in column 2 of Table 6.5.

In the next few paragraphs we analyse the effects of removing import tax on high speed diesel when real private consumption is assumed fixed (SIM1a-Case 1). We then discuss the effects generated by the change in private consumption resulting from the elimination of import tax on high speed diesel in isolation (SIM1a-Case 2). We finally discuss the net result of these two effects which are reported in j (column 3).

Effects of Removing Import tax on High speed Diesel with Fixed Real Consumption

Column 1 in Table 6.5 shows the effects of removing source-discriminating tax on high speed diesel when real consumption is fixed for all the 14 types of household. The purchaser's price of high speed diesel falls by 3.2 per cent when the import tax on it is reduced by 6 per cent. A large share of high speed diesel (about 80 per cent) is used as an intermediate input in the road transport and rail transport industries. The shares of high speed diesel in the total production costs of the road and rail transport industries are 22 per cent and 16 per cent respectively. Road transport and rail transport are the two margin goods. The fall in the purchaser's price of high speed diesel reduces the production cost of these margin goods and, as a result, reduces the purchasers' prices of all commodities. The fall in purchasers' prices leads to reductions in domestic costs of production. Exports expand because, with their selling prices determined in world markets, exporters enjoy a cost-price improvement generated by the deflationary effects of the reduction in transport cost. Import-competing industries also become more competitive and expand. Some of the non-traded goods industries which supply intermediate inputs to these traded-goods industries also expand. Hence, there is an expansion in labour demand by export and import-competing industries; some agricultural industries which supply intermediate inputs; and some service industries such as electricity and margin-goods industries. There is re-allocation of labour resources from non-traded good industries to traded good industries. The decline in domestic prices increases real income of households. However, their consumption does not increase because of our assumption of fixed real consumption. The average propensities to consume for 14 types of households decline between 0.02 and 0.15.

Most of traded goods industries are in the large-scale manufacturing. The small-scale manufacturing and the services sector, each has one traded good industry. Our industry-level results show that increases in output of the traded goods industries from the large-scale manufacturing sector are smaller relative to the increase in output of industries in other sectors. This is caused by the

difference in energy consumption pattern of the industries. The export industry from the small-scale manufacturing sector, *i.e.*, the rice-husking industry has high electricity intensity relative to other export industries in the large-scale manufacturing sector. The latter group of industries have higher intensity of furnace oil. Our detailed results on energy prices show that there is a smaller increase in electricity price relative to the increase in furnace oil price. The production structure of the manufacturing industries allows substitution between furnace oil and electricity. Due to the higher share of electricity in their energy demand, there is a higher substitution of electricity with furnace oil in the rice-husking industries relative to other export industries in the large-scale manufacturing industries.

Column 1 shows that real wages of all four types of labour increase. However, the increases in un-skilled-labour wages are higher relative to the real wage of skilled labour. This is explained by the employment pattern of labour in the industries. Most of the traded-goods industries are capital intensive and have low supply elasticities. Further, the pattern of employment in the base year shows that the unskilled-labour has high share in the labour demand of traded-goods industries, while most of the non-traded-good industries employ a balanced mix of the four types of labour. Hence expansion in traded- and some of the non-traded-goods industries increases the demand for unskilled labour. The nominal wages of unskilled labours rise. Contrary to this, contractions in most of the non-traded good industries reduce the nominal wages of skilled labour. Nevertheless, the real wage of skilled labour increases because there is a higher decline in the CPI relative to the decline in their nominal wages.

Table 6.5 Disaggregation of Effects of Removing Import Tax on High Speed Diesel in SIM1a
(percentage changes)

	Removal of the import tax with Fixed Real Consumption Case 1 (1)	Exogenous Change in Real Consumption Case 2 (2)	Total Effects SIM1a (3)= (1) + (2)
Real GDP	0.01	0.01	0.02
Real private consumption	0.00	0.13	0.13
Trade balance [†]	0.03	-0.37	-0.34
Indirect tax revenue	-0.79	0.10	-0.69
CPI	-0.10	0.39	0.29
GDP deflator	-0.09	0.42	0.33
<i>Real Wages</i>			
Rural-skilled	0.05	0.18	0.23
Urban-skilled	0.02	0.21	0.23
Rural-unskilled	0.17	0.03	0.20
Urban-unskilled	0.11	0.03	0.14
<i>Sectoral Output</i>			
Agriculture	0.03	-0.01	0.02
Oil & gas	0.00	-0.01	-0.01
Large-scale manufacturing	0.02	-0.06	-0.04
Small-scale manufacturing	0.03	0.03	0.06
Services	0.03	0.02	0.05
Fertiliser	0.09	-0.05	0.04
Refinery	-0.15	-0.01	-0.16
Cement	-0.00	0.0	0.00
Natural gas	0.02	-0.01	0.01
Electricity	0.04	-0.06	-0.02

[†] Rs Billion

Effects of Increase in Real Consumption

Our results of Case 1 show that average propensities to consume for 14 types of household decline between -0.02 and -0.15 per cent when we remove the import tax on high speed diesel with fixed real consumption. Conversely it implies that this tax reform increases real consumption of the households between 0.02 and 0.15 per cent. We use these values to shock real consumption of 14 types of household in Case 2 of SIM1a to compute the effects generated by the increase in real consumption in SIM1a results. Column 2 shows the results of Case 2. In the next few paragraphs we discuss these results. In the short run, an expansion in domestic absorption has the following effects (see column 2).

- Overall consumer prices and nominal wages increase. However, the increase in nominal wages is higher than the increase in consumer prices as the latter are a weighted average of prices of domestic and imported goods. The result is an increase in real wages for four types of labour.
- Production in most of the non-traded goods industries increases; especially in those industries which sales largely to private consumption.
- The expansion in domestic production increases the basic prices of domestically produced goods. This makes import-competing and export industries less competitive. This acts to reduce exports and increase imports. The trade balance declines by Rs. 0.37 billions.
- As a result of the expansion in non-traded-goods industries and the contraction of the traded-goods industries, there is a change in the structure of labour demand. The demand for skilled labour increases more than the demand for un-skilled labour. As a result, the increase in the real wage of skilled labour is higher relative to the increase in the real wage of unskilled labour.
- Results on sectoral output show the change in output of traded and non-traded goods industries while most of the non-traded goods industries are in the small-scale manufacturing and service sectors. Most of the traded goods industries are in the large-scale manufacturing sector. The contractions of the traded goods industries are thus shown by the decline in

output of the large-scale manufacturing sector. The expansion of non-traded goods industries in the small-scale manufacturing and service sectors outweighs the decline in output of the traded goods industries in these sectors.

Total Effects of Eliminating Import tax on High Speed Diesel-SIM1a

Thus some of the economic effects (such as the increase in real GDP) produced by the reduction in the import tax on high speed diesel are accelerated in the second round through the effects of the expansion in domestic absorption. Other first-round effects, such as an improvement in the trade balance and a decline in domestic prices are offset by the second round. Column 3 in Table 6.5 shows the net effect of the two phenomena:

- the reduction in the import tax on diesel; and
- the resulting increase in real private consumption.

As shown in Table 6.5, the net effects of a 6 per cent reduction in the import tax on high speed diesel are a 0.02 per cent increase in real GDP and a 0.13 per cent increase in real private consumption. As discussed, both the effects cause increase in real wages for all four types of labour but to different extent. The total effect is a higher increase in the real wage of skilled labour relative to unskilled labour in both urban and rural regions. This is explained by the difference in the sectoral composition of GDP in the two cases (see Columns 1 and 2 in Table 6.5). The sectoral output results show that most of the non-traded goods industries expand in both the cases while export and import-competing industries expand only in the first case; when real consumption for households were fixed. The net effects are an increase in output of non-traded goods industries and a decline in output of traded-goods industries. This causes higher increase in demand for skilled labour relative to unskilled labour.

The difference in real wages of unskilled labour in the two regions is due to their employment patterns. In the base-year, urban-unskilled labour has a significant share in labour employment in traded goods industries which are mainly large-scale manufacturing industries. The rural un-skilled labour has significant share in labour demand of agricultural industries which supply inputs

to both traded and non-traded goods industries. The contraction in non-traded goods industries has a strong negative impact on the employment prospects of urban-unskilled labour, but only a very small effect on the demand for rural-unskilled-labour.

Though total labour supply is fixed by profession, the labour supply function in a region is upward sloping for each profession. A change in relative real wages for a profession between two regions induces migration of labour to the region with higher real wage. Our labour migration results show that there is no inter-region migration of skilled labour. This shows that the net shifts in the demands for skilled labour (after substitution between skilled and unskilled labour) in the two regions are equal. Since national skilled employment is fixed there is no change in skilled-labour employment by region while real skilled wages in the two regions increase by the same extent. For unskilled labour, we observe an increase of 0.01 per cent in rural employment and a decline of 0.01 in urban employment. As discussed, changes in sectoral composition of GDP in this simulation favour demand for rural-unskilled labour more than urban-unskilled labour. A relatively lower increase in the demand for urban-unskilled labour creates a difference in real wages of unskilled labour between the two regions. As a result unskilled labour migrates from urban to rural regions. Thus an upward shift in the supply of unskilled labour in the urban region has positive effects on their wages. This migration improves the supply of unskilled labour in the rural region reducing upward pressure there. As a net effect, there is a decrease in employment of urban-unskilled labour with a small increase in their real wages. This shows that the offsetting upward ward shift in labour supply of urban-unskilled labour is higher than the decline in demand.

We assume that real government expenditure is fixed. Hence, the nominal value of government expenditure increases due to increase in the prices of commodities. The public budget deficit is determined endogenously as the net effect of changes in the nominal value of government's expenditure and its income. In SIM1a, the reduction in the import tax on high speed diesel reallocates

resources from the public budget to private consumption and savings. Consequently it increases the public budget deficit.

With real government expenditure fixed reduction of tax revenue by one base-period dollar increases the government deficit by one dollar and increases household incomes by the same amount. With fixed propensities to save, household savings increase by less than one dollar. Since investment is fixed in real terms, the gap between domestic savings and investments increases. This gap is filled by the deterioration in the trade balance. The trade deficit declines by Rs 0.34 billion

Distributional Effects in SIM1a

Table 6.6 reports the effects on real *per capita* consumption for 14 types of household in SIM1a to SIM1d. Column 1 in Table 6.6 shows the effects on *per capita* real consumption of households when we remove import tax on high speed diesel (SIM1a). There is a positive effect on consumption for all 14 types of household. However, this effect is not uniform across household groups. Variations are caused by the differences in the pattern of consumption and sources of income between household groups. The highest increase in real *per capita* consumption is enjoyed by the middle-income group in the employed category, in both regions. Our results on the CPI and income for 14 types of household show an increase in the CPI and income of each household group. The increase in nominal income is relatively higher than the increase in the CPI for the two middle-income groups. The rural-middle-income group enjoys 0.17 per cent increase, and the urban-middle-income group enjoys 0.19 per cent increase, in real *per capita* consumption. The lowest increase (0.03) is in real *per capita* consumption of the rural high-income group in the employed category. However, its counterpart in the urban region enjoys the second highest increase (0.17 per cent). As shown in Column 1, most of the household groups enjoy an increase in real *per capita* consumption between 0.10 and 0.19 except the two urban low-income groups and the two rural high-income groups which experience 0.06 and 0.04 per cent increase in their real *per capita* consumption.

Table 6.6 Projected Effects on Household Real *per capita* Consumption of
Removing Import Taxes (subsidies) on Petroleum Products
(percentage change)

	(1) (SIM1a) High Speed Diesel -6.0	(2) (SIM1b) Gasoline -36.0	(3) (SIM1c) Kerosene 20.0	(4) (SIM1d) Furnace Oil 85.0	(5) (SIM1) Total Effect of all Shocks
<i>Power of Tariff</i>					
<i>Self-employed</i>					
Rural-low-income	0.15	0.11	-0.15	-0.01	0.10
Urban-low-income	0.06	0.06	-0.14	-0.01	-0.03
Rural-middle-income	0.10	0.07	-0.06	-0.01	0.10
Urban-middle-income	0.10	0.10	-0.09	-0.01	0.10
Rural-high-income	0.04	0.06	0.02	-0.01	0.11
Urban-high-income	0.16	0.15	0.01	-0.02	0.28
<i>Employed</i>					
Rural-low-income	0.15	0.11	-0.15	-0.01	0.10
Urban-low-income	0.06	0.06	-0.14	-0.01	-0.03
Rural-middle-income	0.17	0.17	-0.12	-0.02	0.20
Urban-middle-income	0.19	0.25	-0.17	-0.03	0.24
Rural-high-income	0.03	0.04	0.01	-0.01	0.07
Urban-high-income	0.17	0.17	-0.01	-0.02	0.31
<i>Others</i>					
Rural	0.10	0.09	-0.06	-0.01	0.12
Urban	0.14	0.13	-0.05	-0.02	0.20

Table 6.7 Projected Effects of Removing Import Tax on Petroleum Products
(percentage changes)

	(1)	(2)	(3)	(4)	(5)
	(SIM1a)	(SIM1b)	(SIM1c)	(SIM1d)	(SIM1)
Power of Tariff	High Speed Diesel -6.0	Gasoline -36.0	Kerosene 20.0	Furnace Oil 85.0	Total Effect of all Shocks
Real GDP	0.02	0.02	-0.00	0.00	0.04
Real private consumption	0.13	0.11	-0.10	-0.01	0.13
Trade balance [†]	-0.34	-0.30	0.25	0.05	-0.34
Indirect tax revenue	-0.69	-0.58	0.48	0.19	-0.61
CPI	0.29	0.19	-0.13	-0.02	0.34
GDP deflator	0.33	0.23	-0.15	-0.02	0.39
<i>Real Wages</i>					
Rural-skilled	0.23	0.30	-0.17	-0.03	0.33
Urban-skilled	0.23	0.30	-0.15	-0.04	0.34
Rural-unskilled	0.20	0.15	-0.12	-0.01	0.23
Urban-unskilled	0.14	0.13	-0.08	-0.02	0.18
<i>Sectoral Output</i>					
Agriculture	0.02	-0.00	-0.00	-0.00	0.02
Oil & gas	-0.01	-0.02	0.01	0.00	-0.01
Large-scale manufacturing	-0.04	-0.05	0.03	-0.00	-0.06
Small-scale manufacturing	0.06	0.02	-0.02	-0.01	0.04
Services	0.05	0.03	-0.01	-0.01	0.06
Fertiliser	0.04	-0.03	0.02	0.01	0.02
Refinery	-0.16	-0.28	0.20	0.03	-0.21
Cement	0.00	0.00	-0.00	0.00	0.00
Natural gas	0.01	-0.00	0.00	0.01	0.01
Electricity	-0.02	-0.06	0.04	0.01	-0.03

[†] Rs Billion

6.3.2 The Effects of Removing Import Tax on Gasoline-SIM1b

The second column in Table 6.7 shows the effects of eliminating import tax on gasoline (SIM1b). The effects on real GDP, real private consumption, and the trade balance are similar to the effects observed in SIM1a (for the elimination of import tax on high speed diesel). Real GDP and real private consumption increase by 0.02 and 0.11 per cent respectively. The trade balance deteriorates by Rs 0.3 billion and government revenues decline by 0.58 per cent. There is an increase of 0.20 per cent and 0.23 per cent in the CPI and GDP deflators respectively. These increases in prices are smaller than those resulting from the reduction in the import tax on high speed diesel. However, the difference between the two indices is the same, so the resulting real GDP effect is of the same magnitude.

The mechanism through which the reduction in the import tax on gasoline affects the economy is different from that for high speed diesel. Gasoline is mainly used by the households for private transport and a small share of it is used in public transport. The elimination of the import tax from gasoline reduces its purchaser's price by 15 per cent. Table 6.8 shows that households spend between 9 and 21 per cent of their total expenditure on non-durable transport; this is composed of expenditure on public transport and expenditure on petroleum products (mainly gasoline).

Table 6.8 Share of Non-Durable Transport in Household's Expenditure and their Expenditure Elasticities

Household Types	Non-Durable Transport Expenditure	
	Share in Total Expenditure	Expenditure Elasticity [†]
<i>Self-employed</i>		
Rural-low-income	0.095	0.84
Urban-low-income	0.099	1.06
Rural-middle-income	0.126	0.90
Urban-middle-income	0.138	1.14
Rural-high-income	0.178	1.09
Urban-high-income	0.207	1.48
<i>Employed</i>		
Rural-low-income	0.094	0.84
Urban-low-income	0.099	1.06
Rural-middle-income	0.127	0.91
Urban-middle-income	0.136	1.14
Rural-high-income	0.148	1.11
Urban-high-income	0.203	1.49
<i>Others</i>		
Rural	0.136	0.99
Urban	0.173	1.44

[†] Adjusted for budget shares in the base-year data.

Source: Burney, N. A. and A. H. Khan, (1991)

The reduction in gasoline price increases the real income of households and increases their real household expenditure. This in turn increases domestic absorption. The increase in domestic absorption leads to effects similar to those discussed for the reduction in the tax on high speed diesel. Our experimental results show that the elimination of import tax on gasoline, with fixed real household expenditure causes a decline between 0.13 and 0.23 per cent in the

nominal expenditure of the various types of household. This reduction in household expenditure is required to keep real consumption levels at the base level. Conversely we can say that 15 per cent decline in the price of gasoline causes about 0.13 to 0.23 per cent increase in the income of different household groups. When we allow these changes in households' income to affect their consumption, there is an expansion in private consumption. This expansion leads to a small increase in the CPI. The increase in real private consumption increases the demand for both domestic and imported goods. The basic cost of production increases as the industries expand their production by substituting fixed capital stock with labour. The demand for labour by these industries increases leading to an increase in labour wages. The rise in domestic prices reduces exports demand and increases imports. The demands for labour by these traded-goods industries decline. There is a reallocation of labours between industries and regions. As the net effect real wages and real GDP increase.

Our results reported in column 1 and 2 of Table 6.7 show that removing the import tax on high speed diesel and gasoline has a positive effect on economic growth but also causes a deterioration in indirect tax revenue and the balance of trade. The indirect tax-revenue is major source of the government income. With fixed real consumption of government and real investment, the reduction in indirect tax revenue results in public sector deficit and a deterioration in the trade balance.

As shown in Table 6.4, there are import subsidies (in the sense of Section 5.3.10) on two petroleum products. In the following sections we first discuss the effects of removing the import subsidies on kerosene and furnace oil separately, then proceed to a discussion of the cumulative effects of removing all the import taxes and subsidies on petroleum products.

6.3.3 The Effects of Removing Import Subsidies on Kerosene-SIM1c and Furnace oil -SIM1d

In this section we discuss the simulation results of removing subsidies on the import of kerosene (SIM1c) and furnace oil (SIM1d). In Table 6.7, columns 3 and 4 contain the results of SIM1c and SIM1d respectively. We observe that the reduction in the import subsidy on kerosene decreases real private consumption by 0.10 per cent. The negative effect on real GDP is nearly zero. There is an improvement in the trade balance of about Rs 250 million, and an increase in the government indirect tax revenue of about 0.5 per cent. The mechanism through which the reduction in kerosene subsidy produces these results is the converse of the process discussed for gasoline. Removal of the import subsidy decreases the real income of households, and as a result private consumption and domestic absorption contract.

The effects of removing the import subsidy on furnace oil are very small compared to the effects of changes in the import taxes on high speed diesel, gasoline and kerosene. Furnace oil is an intermediate input used in the manufacturing industries. It has a significant share (between 8 and 27 per cent) in production costs of five small-scale manufacturing industries. Significant shares of the total supply of furnace oil (24 and 15 per cent) are also consumed by the rail transport and steam electricity industries. The increase in the price of furnace oil increases the basic price of electricity generated by the steam electricity industry. However, the purchaser's price of electricity does not increase significantly for three reasons. First, in GE-PAK, four industries generate electricity and the steam electricity industry supplies only 30 per cent of the total supply. Second, there is a substitution possibility between electricity generated by the steam and the combined cycle industries. Third, there is a substitution of furnace oil by natural gas in the steam electricity industry. Among the transport industries, rail transport has only a small share in total transport margins, which are mainly supplied by road transport. Therefore, the increase in the price of furnace oil increases the output prices of only five small-scale manufacturing industries.

These industries produce three investment goods and two consumer goods which are non-traded. Since investments are exogenously given for industries, the demands for investment goods are unaffected by changes in their prices. Hence the increases in the basic prices of investment goods produced by the furnace oil intensive industries are passed on to the capital-goods-formation sector. The nominal investment expenditure increases. The increases in the basic prices of the two consumer goods (produced by furnace oil intensive industries) generate the same qualitative effects as the change in the price of kerosene, it reduces the real income of households. Hence the mechanism through which the removal of the subsidy affects the economy is the similar to that discussed for the kerosene subsidy.

6.3.4 The Cumulative Effects of Removing Import Taxes (Subsidies) on All Petroleum Products (SIM1)

Figure 6.1 shows the cumulative effects of removing all source-discriminating taxes on petroleum products (SIM1).

In Subsections 6.3.1 to 6.3.3, we discussed the mechanisms through which each import tax, or import subsidy, shock affects the economy. In this section we discuss the net effects of removing all these taxes and subsidies. The salient features of the simulation results are as follows.

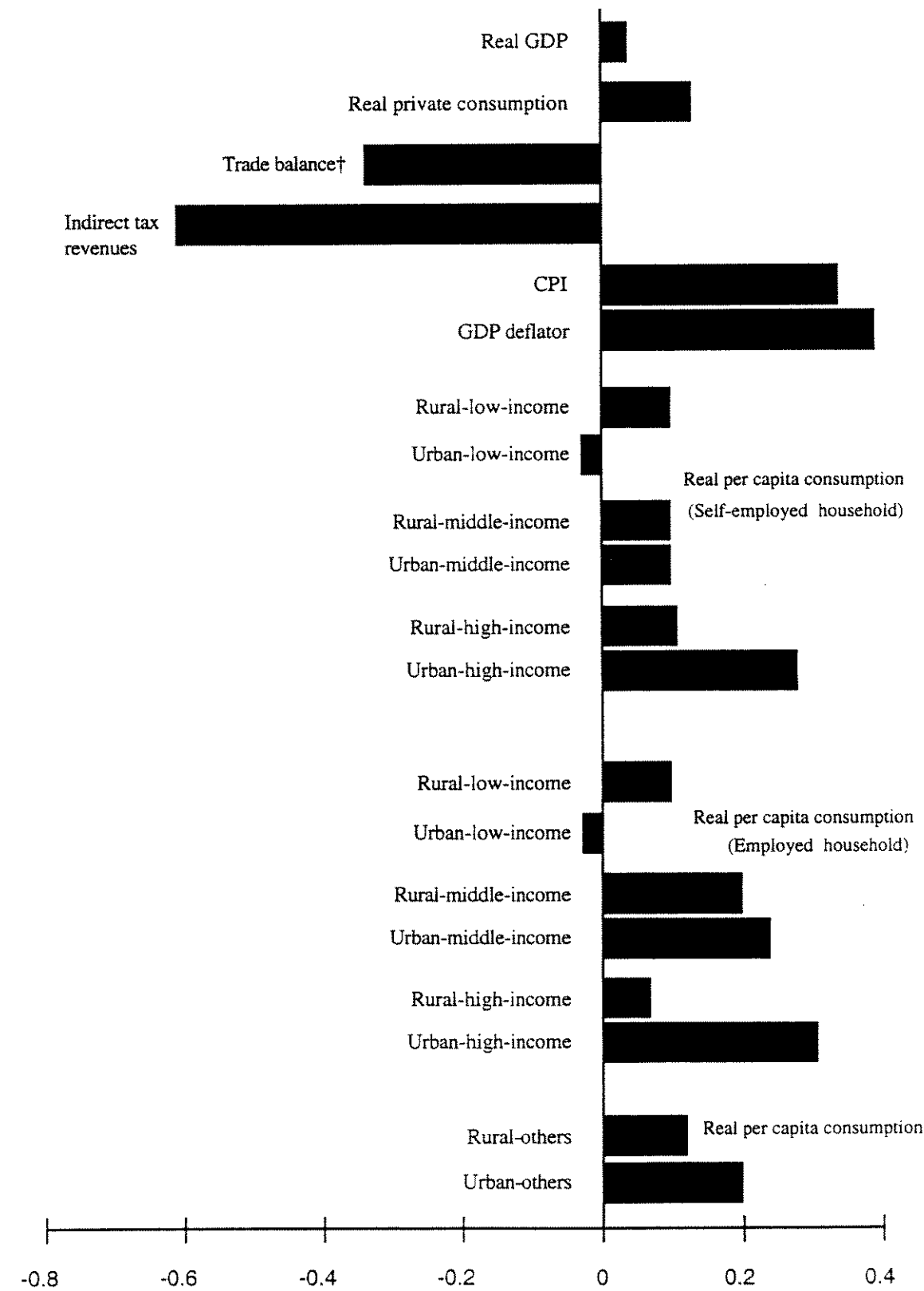
- (i) Removing import taxes and subsidies on petroleum products has positive effects on the economy: real GDP increases by 0.04 per cent and real private consumption increases by 0.13 per cent.
- (ii) Total indirect tax revenues falls by about 0.34 per cent. The resulting public sector deficit is accommodated by a deterioration in the trade balance that amounts to Rs 340 million.
- (iii) In the base year, the revenues generated by the import tax on the two petroleum products are about the same as the subsidies given on the other two products. However, our results show that removing of the inter-product taxes gives a net loss of government revenues.
- (iv) Figure 6.1 shows the cumulative effects of these reforms on households by income groups in self-employed, employed and other household

categories. The effects on three categories are discussed here separately.

(a) In the self-employed category, there are three noticeable features of changes in real *per capita* consumption of households by income and region. First, these reforms have positive effects on all households except on the urban-low income group. There is a decline of 0.03 per cent in real *per capita* consumption of these households. Second, contrary to urban-low income households, there is an increase in the consumption of the rural-low-income group (0.10). Third, there is an increase in real *per capita* consumption of both the middle and high income groups while the increase for the urban-high income group is highest (0.31). As shown in Table 6.6, the removal of the subsidy on kerosene has high negative effects on low-income groups compared to small negative effects on high income groups. Since the urban-low income group receives a small gain from the other two reforms they become net losers. (b) The pattern of changes in real *per capita* consumption of 7 types of household in the employed category is similar to that of the self-employed category except for three groups. First, the middle-income group in the employed category enjoys a higher increase in the consumption compared to its counterparts in the self-employed category, in both the urban and rural regions. This increase is caused mainly by a high increase in real wages of skilled labour which are owned by middle-income groups in both the regions. Second, there is a smaller increase in real *per capita* consumption of the rural-high-income group compared to the increase in the consumption of this group in self-employed category. (c) There are positive effects on real *per capita* consumption of households in the other category for both regions; urban households have a relatively higher increase in their consumption.

(v) Among the 14 types of household, we observe that the urban-high-income group has the highest increase in real *per capita* consumption, in both the employment categories.

Figure 6.1 Cumulative Effects of Removing Import Taxes (subsidies) on Petroleum Products (Percentage Change)



The non-uniform changes in real *per capita* consumption for 14 types of household could be due to differences in their income, or due to differences in their consumption patterns. In Table 6.9 columns 1 to 3 give changes in nominal *per capita* income, the CPI, and real *per capita* consumption by household type. Changes in unit wage and the number of households explain the change in nominal income of each group. As shown in column 5, all the skilled labour is owned by the middle-income groups in the employed category. Therefore, the effects on labour income of these groups are determined by the combined effects of inter-region migration of skilled and unskilled labour and their wages. Change in relative wages of rural and urban labour in each profession induces inter-region migrations of households. Columns 4 give changes in number of households in each household group. The nominal *per capita* income is the nominal income of a household group net of changes in number of households in that group. In the following paragraphs we first discuss the variations in income of 14 types of household (Column 1) and then discuss the variations in the consumer price indices of these groups. These two factors explain the variations in real *per capita* consumption of these groups.

As shown in Table 6.9, the import tax reforms have positive effects on nominal income for all 14 types of household, though to different extent. The nominal income of all the groups increases as returns to primary factors rise. Labour wages constitute a big share in households' income, in particular in income of the low- and middle-income groups. The rise in all 4 types of wage at different extent and the inter-region migration of households mainly explains the variation in income of 14 types of household.

The low-income groups in the two regions rely mainly on income from the wages of unskilled labour. Our results show that nominal wage of rural-unskilled labour increases more than the wage of urban-unskilled labour. In our labour migration function, real wage for a household group is defined as nominal wages deflated by the CPI of that group. The increase in the CPI of rural households in low-income groups is lower than that of the urban households. Thus real wage in the rural region increases more than the urban wages for the

low income groups. This results in migration of the households at margin from the urban region to the rural region. The nominal income of the rural-low-income group rises more than the urban low-income group. The share of unskilled wages is big for the middle-income households in the self-employed category. The higher increase in nominal wages of rural-unskilled labour and a lower increase in the CPI for rural households explains the migration of households from urban to region in this group. The net result is a higher increase in their nominal income. The share of wages in total income of the rural-high-income is small relative to other groups. A big share of their income is from foreign remittances. Thus increase in wages have a smaller effects on their income relative to other groups. The middle-income households in the employed category draw income from both skilled and unskilled labours. For these groups, income from skilled labour constitutes a big share of their income. This share is much higher for the urban households. The higher increase in real wages of rural labour, both skilled and unskilled, induces migration of both skilled and unskilled labours to the rural region in this category. Thus nominal income of this group increases. Though the number of urban households in this category declines by 0.02 per cent but this urban group enjoys higher increase in its nominal income relative to the its rural counterpart due to higher wage for urban skilled labour and higher share of skilled labour in its income from.

Table 6.9 Cumulative Effects of Removing Import Taxes and Subsidies on Petroleum Products on Private Consumption By Household Types (SIM1)

Household Type	(1) Nominal <i>per capita</i> Income	(2) CPI	(3) Real <i>per capita</i> Consump- tion	(4) Number of Households	(5) Share of Skilled Wages in Total Wages
<i>Self-employed</i>					
Rural-low-income	0.54	0.44	0.10	0.03	0.0
Urban-low-income	0.46	0.49	-0.03	-0.03	0.0
Rural-middle-income	0.45	0.35	0.10	0.02	0.0
Urban-middle-income	0.48	0.38	0.10	-0.02	0.0
Rural-high-income	0.33	0.21	0.11	0.00	0.0
Urban-high-income	0.45	0.17	0.28	0.00	
<i>Employed</i>					
Rural-low-income	0.54	0.44	0.10	0.03	0.0
Urban-low-income	0.47	0.50	-0.03	-0.03	0.0
Rural-middle-income	0.55	0.35	0.20	0.02	0.47
Urban-middle-income	0.63	0.38	0.24	-0.02	0.84
Rural-high-income	0.34	0.27	0.07	-0.01	0.0
Urban-high-income	0.49	0.18	0.31	0.01	0.0
<i>Others</i>					
Rural	0.44	0.32	0.12	0.00	0.0
Urban	0.47	0.27	0.20	0.00	0.0

The above differences in nominal income become more significant for the difference in real consumption due to the variations in consumption patterns of household groups. Column 2 in Table 6.9 shows that the increase in the CPI is different for each income group when the prices of consumer items are weighted by expenditure shares for a group. The highest increase in the CPI is for the urban-low-income groups. The increase in the CPI outweighs the increase in the

nominal *per capita* income of the urban-low-income groups and there is a decline in their real consumption. Table 6.9 shows that the two rural-high income groups experience a bigger increase in nominal *per capita* income compared to the two urban low-income groups. Further these rural groups also enjoy a smaller increase in the CPI. Therefore, these groups enjoy an increase in real *per capita* consumption.

In the model there are 53 consumer items. Table 6.10 show the budget shares of kerosene, non-durable transport expenditure, wheat and rice in expenditure of all 14 types of household. These items are more effected by the import reforms relative to other items. The shares in Table 6.9 show the variation in consumption pattern of households across income groups and across region. The shares of kerosene are highest in expenditure for the two urban-low-income groups among all 14 types of household. Contrary to it, the shares of non-durable transport in their total expenditure are lower than the shares for most of the other groups. Our detailed results on the prices of consumer items show that there is a biggest increase in the price of kerosene and a biggest decline in the price of non-durable transport due to reduction in import tax on gasoline and high speed diesel. Hence, as a net effect, the CPI for the urban-low-income groups increases more rapidly than the CPI for other household types. The CPI for the rural-low-income groups have smaller increase relative to the urban-low-income groups. The rural-low-income groups have not only a smaller share of kerosene but have relatively higher shares of wheat and rice. There are smaller increases in the prices of these consumer items relative to other items. The consumer price indices show the net effects on CPI of each household group.

Our results show that the removal of import taxes and subsidies from petroleum products has a negative effect on real *per capita* consumption for households in the urban-low-income group due to the low positive effects on their income, and the high negative effects of increases in consumer prices of goods which have higher shares in their consumption basket.

Table 6.10 Shares of Kerosene and some other Items in Households' Expenditure

Household Type	Share in Household Expenditure			
	(1)	(2)	(3)	(4)
	Kerosene	Non-durable Transport	Wheat	Rice
<i>Self-employed</i>				
Rural-low-income	0.011	0.095	0.132	0.040
Urban-low-income	0.015	0.099	0.085	0.027
Rural-middle-income	0.007	0.126	0.098	0.037
Urban-middle-income	0.010	0.138	0.057	0.030
Rural-high-income	0.004	0.178	0.049	0.021
Urban-high-income	0.003	0.207	0.022	0.018
<i>Employed</i>				
Rural-low-income	0.011	0.094	0.134	0.040
Urban-low-income	0.015	0.099	0.085	0.027
Rural-middle-income	0.008	0.127	0.10	0.037
Urban-middle-income	0.011	0.136	0.58	0.030
Rural-high-income	0.004	0.148	0.57	0.023
Urban-high-income	0.003	0.203	0.23	0.018
<i>Others</i>				
Rural	0.007	0.136	0.088	0.032
Urban	0.007	0.173	0.040	0.023

† Adjusted for budget shares in the base-year data.

Source: Burney, N. A. and A. H. Khan (1991)

6.4 The Effects of Making Sales Tax Rates on Petroleum Products Uniform - SIM2

Our analysis of tax rates in the base year shows that the sales tax rates on petroleum products are not uniform. Table 6.11 shows that there are high taxes on high speed diesel and gasoline while there are subsidies on kerosene, light speed diesel oil and furnace oil. Sales tax rates on petroleum products vary

between -3 and 23 per cent. The weighted-average of tax rates on all the petroleum products is about 13 per cent.

Table 6.11 Values for Exogenous Power of Sales Tax on Petroleum Products in (SIM2)

Petroleum Products	(1) Power of Tax in the Base Year	(2) Percentage Change in the Power of Tax [†]
Kerosene	0.99	14.0
High Speed Diesel	1.19	-5.0
Light Diesel Oil	0.99	14.0
Gasoline	1.23	-8.0
Furnace Oil	0.97	16.0

[†] To make all tax rates equal to 13 per cent which is the weighted average tax rate on petroleum products.

In SIM2 we eliminate the product-discriminating taxes on petroleum products. We shock the power of tax on all the petroleum products to make the tax rates uniform at 13 per cent. In Table 6.11, column 1 contains the power of sales taxes on five petroleum products in the base year. Column 2 reports the corresponding exogenous values of changes in these power of taxes in SIM2. In this section we first discuss the cumulative effects of making sales taxes uniform on all the petroleum products. We then compare the impacts of reforms in sales taxes on petroleum products (SIM2) with the impacts of import-tax reforms (SIM1).

The results of SIM2 are reported in column 2 of Table 6.12. Our results show that there is a 0.11 per cent increase in real private consumption and a 0.02 per cent increase in real GDP when the sales taxes on petroleum products are levied at a uniform rate. The increases in tax rates (on 3 products out of 5) are outweighed mainly by the reduction in tax rate on high speed diesel which has a higher share in the total demand. Thus, the uniformity in tax rates results in a decline of 0.54 per cent in indirect tax revenue. With real government

consumption and real investment fixed, this leads to an increase in trade deficit of Rs 290 million.

Table 6.12 Projected Economic Effects of Tax Reforms in SIM1 and SIM2

Cumulative effects of:	(1) Removing Import Taxes	(2) Making Sales tax Rates Uniform	(3) = (1) + (2)
Real GDP	0.04	0.02	0.06
Real private consumption	0.13	0.11	0.24
Trade balance [†]	-0.34	-0.29	-0.63
Indirect tax revenue	-0.61	-0.54	-1.15
CPI	0.34	0.32	0.66
GDP deflator	0.39	0.36	0.75
<i>Real Wages</i>			
Rural-skilled	0.33	0.21	0.54
Urban-skilled	0.34	0.23	0.57
Rural-unskilled	0.23	0.17	0.39
Urban-unskilled	0.18	0.14	0.32
<i>Sectoral Output</i>			
Agriculture	0.02	0.01	0.03
Oil & gas	-0.01	-0.03	-0.04
Large-scale manufacturing	-0.06	-0.06	-0.12
Small-scale manufacturing	0.04	0.04	0.09
Services	0.06	0.05	0.11
Fertiliser	0.02	-0.04	-0.02
Refinery	-0.21	0.08	-0.12
Cement	0.00	0.00	0.00
Natural gas	0.01	0.02	0.03
Electricity	-0.03	0.01	-0.02
<i>Energy Prices</i>			
Kerosene	12.00	10.73	22.74
High speed diesel	-3.0	-3.47	-6.44
Light diesel oil	0.89	4.63	5.52
Gasoline	-14.95	-5.31	-20.27
Furnace oil	6.61	5.98	12.60
Electricity	0.49	0.70	1.19
Natural gas	0.51	0.93	1.44

[†] Rs Billion. Note: Column 1 and column 2 might not add up to column 3 due to rounding off.

The increase in domestic absorption raises domestic prices; the CPI and the GDP deflator increase by 0.32 and 0.36 per cent respectively. There is a smaller increase in the CPI because it is a weighted-average of domestic and imports prices and there is no increase in imports prices. Real wages of the four types of labour rise as nominal wages rise more than the CPI. The increase in real wage for skilled labour is relatively higher than that for unskilled labour due to expansion in non-traded goods industries which are the major employer of skilled labour. Output of traded goods industries declines as increases in domestic prices make them less competitive. Output of the large-scale manufacturing sector declines as most of the major exports and import-competing industries are in this sector.

In columns 1 and 2 of Table 6.12 we report the results of reforms in import taxes and sales taxes on petroleum products respectively. Comparing the macroeconomic effects of the two reforms gives the following insights.

- The net effects of the reforms in two simulations are qualitatively similar but the impacts of sales-tax reforms for petroleum products are smaller in magnitude than the effects of the import-tax reforms. This is explained by the smaller decline in the overall tax rates in SIM2 which results in a smaller increase in domestic absorption. The changes in sales taxes differ from changes in import taxes in two respects. First there is an increase in sales tax on light diesel oil in SIM2 while there is no change in its import tax in SIM1. Second, the increase in sales tax on a commodity increases the tax on its domestic production and imports uniformly while increase in the import tax increases only cost of its import. Therefore reduction in overall tax rate is smaller in SIM2 in spite of smaller increase in sales taxes on kerosene and furnace oil in it relative to SIM1. Further, there are reductions in taxes on two products in both the simulations. The reduction shocks are smaller in SIM2 compared to SIM1. Especially the reduction in sales tax on gasoline in SIM2 is much smaller than the reduction in SIM1.
- Real wages by profession and region increase in both simulations. However, the difference between rural and urban wages for unskilled

labour is smaller in SIM2. There is a smaller increase in real wage of rural-unskilled labour in SIM2 relative to SIM1. This difference is mainly caused by the increase in the price of light diesel oil in SIM2 and its effects on the agriculture sector. The agriculture sector has high intensity of rural-unskilled labour. A slower increase in output of the agriculture sector in SIM2 relative to SIM1 explains a smaller increase in real wages of rural-unskilled labour in SIM2 relative to SIM1. Light diesel oil is mainly used in the agriculture sector. A big increase in the price of light diesel oil in SIM2 increases the cost of production in this sector. Though, there is a substitution of light diesel oil with electricity in this sector, the net effect is an increase in the production cost and slower increase in output of the agriculture sector in SIM2 relative to SIM1.

- Most of the industries in the agriculture sector face no direct import competition but the rice and cotton industries supply raw material to the major export industries. The industry-level results show that the decline in output of two cotton industries (in the agriculture sector) is higher in SIM2 relative to SIM1. The imports of cotton yarns become cheaper in SIM2 when there is an increase in production costs of cotton due to the increase in the price of light diesel oil. The imports of cotton yarns increases and the production of cotton and cotton yarn decline (cotton yarn industry is in the large-scale manufacturing sector).
- In the large-scale manufacturing sector, the lower reduction in output of major export industries is balanced out by the higher reduction in output of cotton yarn industry in SIM2 relative to SIM1. Therefore, the large-scale manufacturing sector contracts to the same extent in the two simulations.
- The small-scale rice processing industry is one of the major export industry in the small-scale manufacturing sector. This industry has a higher electricity intensity compared to other export industries but it also has a higher intensity of unskilled labour (both rural and urban). Thus a smaller increase in labour wages in SIM2 relative to SIM1 outweighs the increase in electricity cost of this industry. The net effect is much smaller

decline in its output which results in expansion of the small-scale manufacturing sector in SIM2 to the extent of increase in SIM1.

- The demand for electricity increases due to substitution of light diesel oil with it in the agriculture sector and smaller decline in the output of electricity intensive industry such as small-scale rice-husking industry. Therefore there is an increase in output of electricity sector in SIM2 compared to the decline in it in SIM1. In line with this, the output of natural gas industry also increases which is one of the major fuel in electricity production. There is a higher increase in output of natural gas industry in SIM2 relative to SIM1. In both the simulations, there is a substitution of domestically produced fertiliser with imported fertiliser. Natural gas is used as a raw material in fertiliser industry and has a big component in the production cost. There is a bigger increase in the price of fertiliser in SIM2 (relative to SIM1) when the price of natural gas price increases. Therefore there is a reduction in consumption of fertiliser and its domestic production in SIM2.
- In SIM1, imports of high speed diesel and gasoline rise and their domestic production decline due to reduction in import tax on these products. Because of the higher shares of these two products in the output of the refinery industry, the net result is contraction of the refinery industry in SIM1. Contrary to SIM1, reduction in sales tax on these products in SIM1 induces higher production of these commodities and reduction in production of kerosene, light diesel oil and furnace oil. Due to higher share of high speed diesel and gasoline in production, the increases in their production outweigh the reduction in output of other three petroleum products. Therefore, there is an increase in output of refinery industry in SIM2. We observe a smaller increase in imports of high speed diesel, and gasoline and a smaller decline in imports of kerosene and furnace oil.

The above comparison shows that the major difference between the two simulations is in their effect on energy producing and energy-intensive industries. In SIM1, output of refinery and electricity industries decline and

output of fertiliser industry increase. Contrary to this, output of refinery and electricity industries increase and output of fertiliser industry declines in SIM2. In both the simulations output of the oil & gas industry decline, and output of natural gas increase but at a larger extent in SIM2.

The comparison of macro-economic effects in the two simulations shows that the positive effects of the reform in import taxes (SIM1) are higher relative to SIM2. Conversely, we can say that the source-discriminating taxes on petroleum products distort the economy more than do the product-discriminating taxes. In the next few paragraphs, we discuss the difference in the distributional impacts in the two simulations.

Table 6.13 Projected Change in Real *per capita* Consumption of Removing Import taxes and Making Sales Tax Rates Uniform on Petroleum Products

	(1)	(2)	(3)
	Removing	Making	= (1) + (2)
	Import Taxes	Sales tax Rates	
Cumulative effects of	(SIM1)	Uniform	(SIM3)
	(SIM2)		
<i>Self-employed</i>			
Rural-low-income	0.10	0.07	0.17
Urban-low-income	-0.03	-0.04	-0.07
Rural-middle-income	0.10	0.09	0.19
Urban-middle-income	0.10	0.07	0.17
Rural-high-income	0.12	0.09	0.21
Urban-high-income	0.28	0.24	0.52
<i>Employed</i>			
Rural-low-income	0.10	0.06	0.16
Urban-low-income	-0.03	-0.04	-0.07
Rural-middle-income	0.20	0.13	0.33
Urban-middle-income	0.25	0.15	0.40
Rural-high-income	0.07	0.04	0.11
Urban-high-income	0.31	0.23	0.54
<i>Others</i>			
Rural	0.12	0.09	0.21
Urban	0.20	0.16	0.36

Table 6.13 shows the effects on real *per capita* consumption for households by region, income group, and employment category, in SIM1 and SIM2. The comparison of the two simulations' results shows the followings.

- The pattern of changes in real *per capita* consumption is very similar in the two simulations. In both the simulations, All the household groups enjoy increase in real *per capita* consumption except the two urban low-

income groups. In both the simulations, high-income groups enjoy the biggest increase in real *per capita* consumption in the urban region. In the rural region, the middle income groups either enjoy the biggest increase in real *per capita* consumption or enjoy the increase comparable to the high-income groups. In both the simulations, the effects on real *per capita* consumption for rural households are more uniform across the income groups in the self-employed category. Contrary to this, there are wide differences in the real *per capita* consumption of urban-household groups and among the rural-household groups in the employed category.

- Compared to SIM1, the increase in real *per capita* consumption in SIM2 is smaller for the 12 types of household groups in SIM2. The decline in real *per capita* consumption for two urban low-income groups is bigger in SIM2 relative to SIM1. The difference between real *per capita* consumption in the two simulations is smallest for the two urban-low income groups (0.01 percentage point) and is between 0.03 and 0.10 percentage point for all other household groups.

In the following paragraphs we present the decomposition of real *per capita* consumption in SIM2 to get an insight of these two observations. Columns 1 to 3 in Table 6.14 report the effects on nominal *per capita* income, the CPI and real *per capita* consumption in SIM1 and columns 4 to 6 contain these results for SIM2. The difference between the income and the CPI for a household group gives us the effect on real *per capita* consumption for it in a simulation.

As shown in column 3 and 6 of Table 6.14, the relatively higher increase in consumer prices of urban low-income groups outweighs the increase in their nominal income. As a result, real *per capita* consumption for urban low-income groups declines. For all other income groups, the higher increase in nominal income outbalanced the increase in their consumer price indices. As a result, the real *per capita* consumption for all other income groups increases.

Table 6.14 Effects on Real *per capita* Consumption By Household Types of Making Sales Tax rates Uniform on Petroleum Products (SIM2)

Household Type	SIM1			SIM2		
	(1) Nominal <i>per capita</i> Income	(2) CPI	(3) = (1)-(2) Real <i>per capita</i> Consump- tion	(4) Nominal <i>per capita</i> Income	(5) CPI	(6) = (4) - (5) Real <i>per capita</i> Consump- tion
<i>Self-employed</i>						
Rural-low-income	0.54	0.44	0.10	0.47	0.40	0.07
Urban-low-income	0.46	0.49	-0.03	0.41	0.45	-0.04
Rural-middle-income	0.45	0.35	0.10	0.42	0.33	0.09
Urban-middle-income	0.48	0.38	0.10	0.43	0.36	0.07
Rural-high-income	0.33	0.21	0.12	0.30	0.21	0.09
Urban-high-income	0.45	0.17	0.28	0.42	0.18	0.24
<i>Employed</i>						
Rural-low-income	0.54	0.44	0.10	0.46	0.40	0.06
Urban-low-income	0.47	0.50	-0.03	0.41	0.45	-0.04
Rural-middle-income	0.55	0.35	0.20	0.46	0.33	0.13
Urban-middle-income	0.63	0.38	0.25	0.51	0.36	0.15
Rural-high-income	0.34	0.27	0.07	0.30	0.26	0.04
Urban-high-income	0.49	0.18	0.31	0.42	0.19	0.23
<i>Others</i>						
Rural	0.44	0.32	0.12	0.39	0.30	0.09
Urban	0.47	0.27	0.20	0.43	0.27	0.16

Compared to SIM1, there are smaller increases in nominal *per capita* income for all groups in SIM2. Similarly there are smaller increase in the CPI for

all the groups except for two urban high-income groups. There is higher increase in the consumer price indices for the these two groups. The CPI for a household group is the average of the prices of consumer items weighted by the shares of these items in its total expenditure. Our detailed results on the prices of consumer items show that there are smaller increases in most of the prices in SIM2 compared to SIM1. The prices of electricity, natural gas and kerosene increase in both the simulations. However, there are higher increases in the prices of electricity and natural gas in SIM2. Further the price of non-durable transport decline in both the simulations but they have smaller decline in SIM2. The consumption patterns of the households show that the shares of non-durable transport item, electricity and natural gas are highest for the two urban-high income groups. Therefore, the consumer price indices for urban high-income group are higher in SIM2 relative to SIM1. Similarly there are smaller difference in the CPI for other middle and high income groups due to the higher shares of these consumer items in their expenditure. As a result, there are smaller increases in real *per capita* consumption for most of the middle- and high-income groups.

Contrary to this, there are smaller increase in the prices of kerosene and food items in SIM2. The shares of kerosene and food items are highest for the low-income groups. Thus relatively smaller increase in kerosene and food items in SIM2 benefits the low-income groups in particular two urban-low income groups. Their real *per capita* consumption deteriorates by an additional 0.01 per cent while the other groups experience smaller increase in real *per capita* consumption in SIM2 to the extent of .03 to 0.10 percentage point relative to SIM1.

The comparison of rural-low-income groups with their urban counterparts shows that the shares of kerosene in expenditure are smaller for rural households but the shares of food items are higher for most of the rural households. The smaller increase in the prices of these agriculture-based items benefit the rural-low income groups more relative to their urban counterparts while the smaller increase in kerosene price benefits the urban households more than rural households. Therefore, there is a smaller increase in the CPI for the low-income

groups to the same extent in the two regions. As discussed, there are smaller increases in wages for rural-unskilled labour in SIM2 relative to SIM1 which results in a smaller increase in nominal income of the rural households. This causes a smaller increase in real *per capita* consumption for the rural low-income groups in SIM2 relative to SIM1 and wipes out the benefit of the reform by 0.03 percentage points. For example, the rural low-income groups experiences an increase of 0.40 per cent in the CPI (compared to 0.44 in SIM1) but it also experiences a 0.47 increase in nominal *per capita* income compared to 0.54 per cent increase in SIM1. The net effect is an increase of 0.07 per cent in real *per capita* consumption compared to a 0.10 per cent increase in SIM1.

6.5 Cumulative Effects of Removing Source- and Product-discriminating Tax Rates on Petroleum Products-SIM3

In this section we present the cumulative effects of removing distortions in import and sales taxes on petroleum products. Figure 6.2 shows that the net impacts of these reforms are: positive effects on real GDP and aggregate real private consumption; and negative effects on government revenues and the balance of trade. There are positive effects on real *per capita* consumption for all 14 types of household except for the two urban-low-income groups.

As shown in Figure 6.2, there is an increase of 0.06 per cent in real GDP, and of 0.24 per cent in real private consumption. However, there is a loss of Rs 630 million in the balance of trade and a decline of 1.15 per cent in total indirect tax revenue.

Figure 6.2 also shows the cumulative effects on real *per capita* consumption of 14 types of household. In the urban-self-employed category, the low-income group experiences a decline of 0.07 per cent in real *per capita* consumption, while the middle-income group enjoys some increase. The high-income group enjoys the highest increase in real *per capita* consumption of 0.52 per cent. A similar pattern of changes in real *per capita* consumption emerges for the urban-employed category. The middle- and high-income groups are benefited

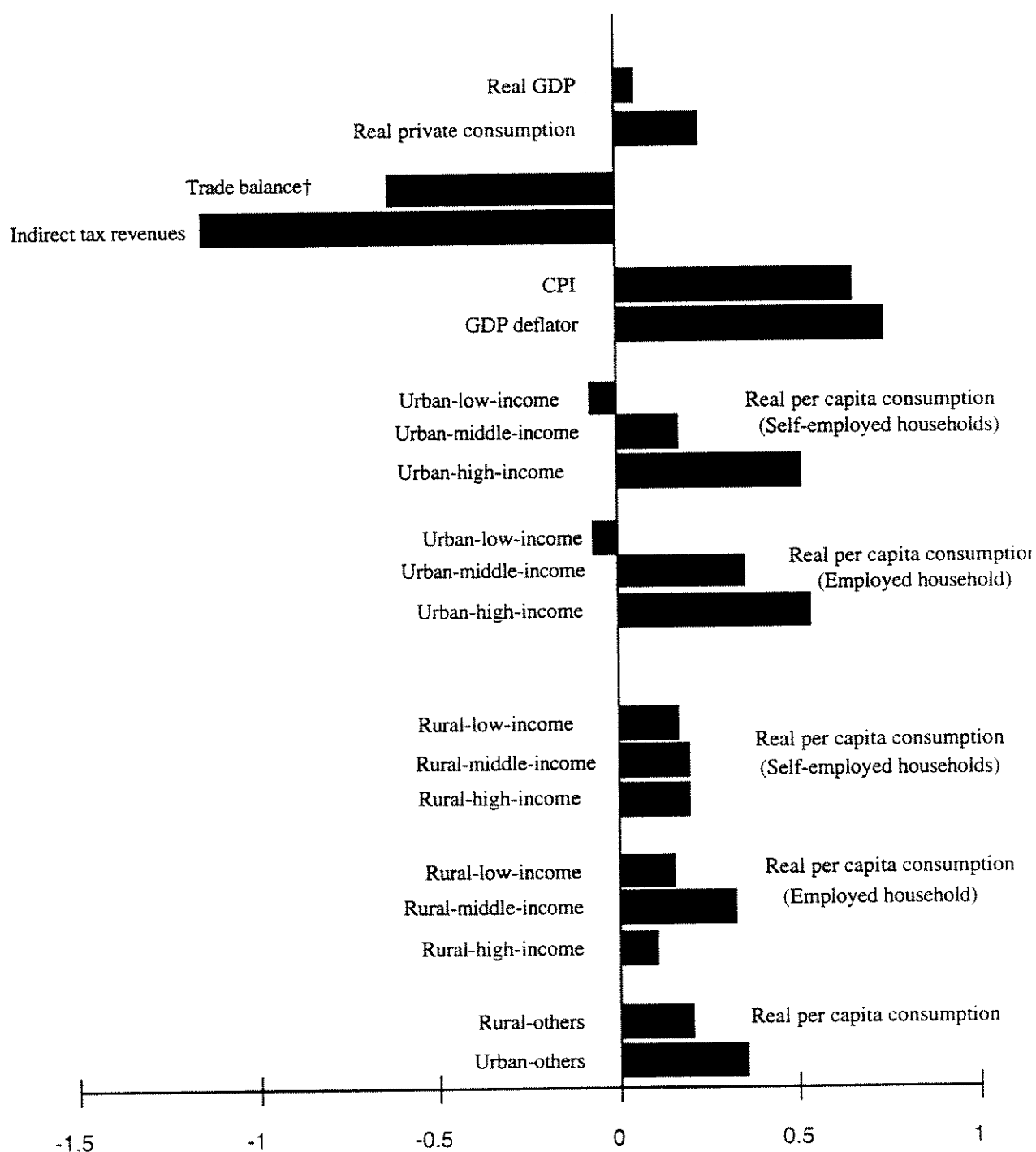
by the changes in the taxes. The low-income group remains a net loser even in the urban-employed category.

A different pattern of changes in real *per capita* consumption emerges for rural households. All 7 types of household enjoy increase in the consumption. In the rural-self-employed category, the increase in real consumption is at about the same extent for all the income groups. Contrary to this, the middle-income group enjoys highest increase in real *per capita* consumption in the employed category.

The main features of the effects of petroleum products reforms are as follows:

- the two urban-low income groups are the net losers;
- the rural-low-income groups benefit, in contrast to their urban counterparts; and
- the two urban-high-income groups are the biggest winners while urban- and rural-middle-income groups in the employed category are the second biggest winners.

Figure 6.2 Cumulative Effects of Removing Source- and Product-discriminating Taxes on Petroleum Products (SIM3)



† Rs Billion

Variations in real *per capita* consumption across income groups in a region are mainly explained by the differences in wages of skilled and unskilled labour; the shares of skilled and unskilled labour in the income of households;

and differences in the consumption pattern of households across income groups. The inter-regional differences in *per capita* consumption for households are mainly explained by the difference in the wages between regions and differences in the consumption pattern between two regions. We have discussed these differences in the previous sections. In this section we only point out the major cause.

Our discussion in Section 6.3 shows that the effects of change in the price of kerosene and gasoline are not uniform across income groups and across regions (see Table 6.6 where the effects of a change in each tax are reported individually). In particular, the increase in the price of kerosene declines real *per capita* consumption of urban-low income group. The results of SIM1 and SIM2 show that the biggest changes are in the prices of kerosene and gasoline. As a net effect of these reforms, the price of kerosene increases by about 23 per cent and gasoline price declines by about 20 per cent. Thus removing of source- and product-discriminating taxes on petroleum products according to efficient taxation rules benefits all the household groups except urban-low-income group. The decrease in the price of gasoline has more positive effects on middle- and high-income groups relative to low-income groups. The benefit generated by the reform in gasoline price is not enough for the two urban-low-income groups to compensate the negative effects generated by the increase in the price of kerosene. The increases in consumer price indices for the two urban-low income groups outweigh the increase in their income.

The change in the price of high speed diesel gives the least distributional effects. The price of high speed diesel decline by about 6 per cent which is much smaller compared to the changes in the prices of kerosene and gasoline. An other big increase is in the price of furnace oil. The effects of a change in the price of furnace oil are very small in every respect. Hence, changes in the prices of high speed diesel, furnace oil and light diesel oil are less important than changes in the prices of gasoline and kerosene for the distributional effects of these reforms.

6.6 Effects of Revenue-Neutral Reforms for Source- and Product-discriminating Taxes on Petroleum Products-SIM3N

The results of SIM3 show that there is a big negative effect on total indirect tax revenues when we abolish import taxes and subsidies (which are source-discriminating) and product-discriminating taxes on petroleum products. These reforms give a deficit in the public budget and a deterioration in the balance of trade. In SIM3N we simulate the effects of these tax reforms in a revenue-neutral environment. The model computes a uniform change in the existing power of taxes on all commodities to make up the loss in total indirect tax revenues which is resulted from the reforms in the taxes on petroleum products.

In this section we discuss the results of SIM3N. Table 6.15 compares the cumulative effects of the reforms in petroleum product taxes (SIM3) with their effects when combined with a uniform tax on all commodities (SIM3N). Since the model is linear, we can separate the effects of an additional uniform tax on all commodities by subtracting the result of SIM3 from SIM3N. Column 3 in Tables 6.15 shows these results.

Comparison of Column 1 and Column 2 in Table 6.15 shows that an additional tax at a uniform rate does not wipe out completely the benefits of the reforms in the taxes on petroleum products. The results of SIM3N show that the abolition of source- and product-discriminating taxes on petroleum products increases real GDP and real private consumption by 0.04 per cent; without incurring any loss in total indirect-tax revenues.

An increase of 0.09 per cent in the power of indirect tax on all commodities is required to compensate for the loss in total indirect tax revenues. Since this increase in the tax rate is the change in the power of tax, it implies an increase in the tax rate on commodities that are not taxed in the base year.

The additional tax in SIM3N keeps total indirect tax revenue constants and as a result it offsets the decline in the trade balance by Rs 300 million. However, there still remains a gap between savings and nominal expenditure on investment; the later increases as a result of increases in the prices of investment

goods while real investment is fixed. This causes a deterioration of Rs 170 million in the trade balance in SIM3N.

Table 6.15 Effects of Removing Import Taxes (subsidies) and Making Sales Tax Rates Uniform on Petroleum Products

	(1) SIM3	(2) SIM3N	(3) = (2) - (1)
Real GDP	0.06	0.05	-0.01
Real private consumption	0.24	0.12	-0.12
Trade balance [†]	-0.63	-0.17	0.46
Indirect tax revenue	-1.15	0.00	1.15
Uniform tax rate	-	0.09	0.09
CPI	0.66	0.24	-0.42
GDP deflator	0.75	0.31	-0.44
<i>Real Wages</i>			
Rural-skilled	0.54	0.17	-0.37
Urban-skilled	0.57	0.15	-0.42
Rural-unskilled	0.39	0.21	-0.18
Urban-unskilled	0.32	0.11	-0.21
<i>Sectoral Output</i>			
Agriculture	0.03	0.04	0.01
Oil & gas	-0.04	-0.03	0.01
Large-scale manufacturing	-0.12	-0.05	0.07
Small-scale manufacturing	0.09	0.05	-0.04
Services	0.11	0.08	-0.03
Fertiliser	-0.02	0.00	0.02
Refinery	-0.12	-0.13	-0.01
Cement	0.00	-0.00	0.00
Natural gas	0.03	0.04	0.01
Electricity	-0.02	0.05	0.07

[†] Rs Billion

Column 3 shows that the additional tax reduces the increases in real wages of labour in the two regions. This reduction is higher for the skilled labour. The decline in domestic absorption and the resulting decline in real wages helps to improve the exports and import-competing industries. We observe a significant increase in the output of large-scale manufacturing industries and a decline in the non-traded good sectors such as small-scale manufacturing and services sectors when an additional tax is levied (see Column 3 in Table 6.15). The net effect of all the tax reforms (SIM3N) is a smaller decrease in output of the large-scale manufacturing industries and a smaller expansion in the services and small-scale manufacturing industries.

Our analysis of tax reforms shows that positive effect of the reforms on aggregated real consumption of households is not uniform across income groups and regions. Table 6.16 compares the effect on real *per capita* consumption of households in SIM3 and SIM3N. In Table 6.16, column 1 contains the cumulative effects of the import- and domestic-tax reforms whilst column 2 reports these effects in a revenue-neutral environment. Comparing column 2 to column 1, we note the following.

- There is a larger negative impact (-0.20) on real *per capita* income of low-income groups in the urban region in SIM3N. The positive effects for the rural-low-income groups are wiped out by the additional tax. The net impacts are declines of -0.01 per cent in real *per capita* income for rural-low-income groups.
- The additional tax reduces the positive effects on real per capita consumption of households in most of the middle- and high-income groups but these households still enjoy a net gain in real *per capita* consumption between 0.04 and 0.38 per cent (see column 2).
- The two urban-high-income groups remain the biggest winners in SIM3N.
- Only the rural-high-income (employed) group experiences an increase in its real consumption in SIM3N. Our results show that the nominal per capita income of this group increases by 0.27 per cent in SIM3N compared to 0.64 per cent increase in SIM3. However, there is much smaller increase

in its CPI in SIM3N. This group's CPI increases by only 0.12 per cent in SIM3N compared to 0.53 per cent increase in SIM3. As a result, real *per capita* consumption of this group increases.

In brief, the revenue-neutral tax reforms of petroleum products have negative effects on the real *per capita* consumption of households in the low-income groups but have positive effects on real per capita consumption for all high-income and the middle-income groups in two regions.

Table 6.16 Projected Changes in Real *per Capita* Consumption by Household Type in SIM3 and SIM3N

Household Type	(1) SIM3	(2) SIM3N	(3) = (2) - (1)
<i>Self-employed</i>			
Rural-low-income	0.17	-0.01	-0.18
Urban-low-income	-0.07	-0.20	-0.13
Rural-middle-income	0.19	0.08	-0.11
Urban-middle-income	0.17	0.01	-0.16
Rural-high-income	0.21	0.21	0.00
Urban-high-income	0.52	0.38	-0.14
<i>Employed</i>			
Rural-low-income	0.16	-0.01	-0.17
Urban-low-income	-0.07	-0.20	-0.13
Rural-middle-income	0.33	0.12	-0.21
Urban-middle-income	0.40	0.04	-0.36
Rural-high-income	0.11	0.15	0.04
Urban-high-income	0.54	0.35	-0.19
<i>Others</i>			
Rural	0.21	0.11	-0.10
Urban	0.36	0.20	-0.16

6.7 Effects of Removing Use-discriminating Taxes on Electricity Sales

As discussed in Chapter 2, there are wedges in the tax rates on electricity sales to five consumer categories. In this section we discuss the effects of removing these wedges. Table 6.17 shows the power of user-discriminating taxes on electricity for five major consumer categories and the hypothetical percentage changes in them. There is a 3 per cent tax on electricity sales on aggregate in 1983-84. The required changes are computed assuming that each consumer category pays a 3 per cent tax. According to Table 6.17, the power of the tax on electricity sales to the agriculture sector and households should be increased by 36 and 83 per cent respectively. The power of user-discriminating tax on electricity to the large-scale and small-scale manufacturing sector, and the service sector should be decreased by 36, 25 and 29 per cent respectively. We simulate the effects of these hypothetical changes in the power of user-discriminating taxes on electricity in SIM4a to SIM4e. Table 6.18 reports these simulation results. In the following subsections, we discuss the effects of removing the tax (subsidy) on electricity sales to each consumer category, then go on to a discussion on the cumulative effects of these tax reforms.

Table 6.17 Values for Exogenous Power of User-discriminating Taxes on Electricity Sales

User Category	Power of Tax in the Base Year	Percentage Change in the Power of Tax†
Agriculture sector	0.76	36.0
Households	0.56	83.0
Large-scale manufacturing sector	1.61	-36.0
Small-scale manufacturing sector	1.38	-25.0
Services sector	1.46	-29.0

† These shocks are given in SIM4a- SIM4e, SIM4 and SIM4N to the user-discriminating tax variables for electricity.

6.7.1 Effects of Removing Subsidy on Electricity Sales to Agriculture

- SIM4a

As discussed, a 36 per cent increase is required in the power of the tax on electricity sales to the agriculture sector to remove the implicit subsidy on electricity sales to this sector. Our results show that the price of electricity for the agriculture sector increases by 35 per cent and it reduces by 1 per cent for all other consumer categories when the subsidy is removed on electricity sales to agriculture. On average we observe reduction in overall domestic prices; the CPI decreases by 0.31 per cent and the GDP deflator declines by 0.35 per cent. This reduction is stimulated by the decline in domestic absorption due to increase in the tax rate on electricity sales to the agriculture sector. The model projects a decrease of 0.09 per cent in real private consumption and an increase of Rs 0.24 billion in the trade balance. The net effect is a zero change in real GDP. On the income side of GDP, total indirect tax revenue increases by 0.05 per cent while the returns to labour and land decline by 0.46 per cent, and the return to capital declines by 0.44 per cent.

The reduction in domestic prices improves competitiveness of the export industries and the import-competing industries. As a result, on the sectoral basis, we observe that there is an increase of 0.08 per cent in output of the large-scale manufacturing industries, while there is a decline in output of the non-traded-goods industries. As shown in Table 6.18, apart from the electricity sector, the major decline occurs in output of the small-scale manufacturing industries (-0.04) relative to a small decline in the oil & gas, natural gas, fertiliser and agricultural industries. Since most of the small-scale manufacturing industries are non-traded goods industries and final private consumption has the biggest shares in their sales, the demand for their output declines when private consumption contracts. The agricultural industries provide inputs to both types of manufacturing industries. The demand for the agricultural inputs increases from the traded-goods industries while the agricultural inputs demand from the small-scale manufacturing industries decline. The net effect is a decline in output of the agricultural industries. There is a substitution of electricity for light diesel

oil in the agricultural industries and a rise in the demand for light diesel oil from the large-scale manufacturing industries. We observe that the refinery industry experiences the biggest increase in output. In contrast, the natural gas industry experiences a decline in its output because of the lower demand for natural gas by the electricity industries. Electricity production declines by 0.12 per cent as a result of removing the subsidy from its sales to the agricultural industries.

Table 6.18 Effects of Removing User-discriminating Taxes on Electricity
(percentage changes)

	(1)	(2)	(3)	(4)	(5)
	SIM4a	SIM4b	SIM4c	SIM4d	SIM4e
			Large- Scale	Small- Scale	
Change in the Power of Implicit Tax on:	Agricul- ture 36.0	House- holds 83.0	Manufac- turing -36.0	Manufac- turing -25.0	Services -29.0
Real GDP	0.00	0.06	0.06	0.02	0.01
Real private consumption	-0.09	-0.42	0.21	0.21	0.13
Trade balance [†]	0.24	1.61	-0.38	-0.44	-0.40
Indirect taxes	0.05	4.46	-2.41	-0.94	-1.06
CPI	-0.31	-0.86	0.90	0.86	0.36
GDP deflator	-0.35	-1.09	0.91	0.95	0.39
<i>Real Wages</i>					
Rural-skilled	-0.24	-2.24	1.25	0.65	0.38
Urban-skilled	-0.23	-1.39	1.26	0.60	0.46
Rural-unskilled	-0.15	-0.71	0.30	0.38	0.14
Urban-unskilled	0.11	-0.20	0.40	0.24	0.20
<i>Sectoral Output</i>					
Agriculture	-0.01	0.20	-0.06	0.07	-0.02
Oil & gas	-0.01	-0.08	-0.08	0.01	-0.01
Large-scale manufacturing	0.08	0.43	0.50	-0.29	-0.06
Small-scale manufacturing	-0.04	0.11	-0.13	0.24	0.04
Services	-0.00	0.03	-0.05	0.03	0.03
Fertiliser	-0.01	0.90	0.61	0.16	-0.06
Refinery	0.10	-0.06	0.03	-0.03	-0.02
Cement	0.00	0.00	0.00	0.00	0.00
Natural gas	-0.02	-0.29	-0.17	0.07	-0.02
Electricity	-0.12	-2.21	1.60	0.54	-0.05

[†] Rs Billion

The changes in the pattern of demand and production of commodities affect the real wages of four types of labour. As shown in Table 6.18, there are three noticeable changes in the real wages, as follows.

- Real wages decline for all categories of labour, except for the urban-unskilled labour. The increase in the real wage of urban-unskilled labour is mainly caused by the expansion in the large-scale manufacturing industries. The urban-unskilled labour has an 88 per cent share in total demand for labour in these industries.
- There is a decline of about 0.23 per cent in real wages of skilled labour in the rural and urban regions. The major employers of skilled labour in the two regions are the services, steam electricity, natural gas and hydro electricity industries. Though the services industries experience negligible contraction in their output, nevertheless, the contraction in the electricity and natural gas industries causes a reduction in overall demand for skilled labour. In particular, the steam-electricity industry is highly labour intensive; labour accounts for 48 per cent of total costs and of which 26 per cent is skilled labour.
- There is a smaller decline (-0.15) in real wage of rural-unskilled labour relative to skilled labour. Rural-unskilled labours have a large share in labour demand by the agricultural industries. A relatively smaller decline in output of these industries (compared to the reduction in output of the electricity and services industries) causes a smaller decline in real wage of rural-unskilled labour compared to the rural-skilled labour.

In Table 6.19, column 1 shows the effects on real *per capita* consumption when we remove the subsidy on electricity sales to the agriculture sector. The pattern of changes in real *per capita* consumption for the 14 types of household is summarised below.

- The urban-middle-income group, in the employed category, experiences the biggest decline (-0.17) in real *per capita* consumption. Its counterpart in the rural region faces a 0.15 per cent decline in the consumption. These households enjoy relatively higher decline in their consumer price indices relative to the other groups due to the decline in the price of electricity for them. They also suffer a relatively high loss of income compared to the

other groups, when wages of skilled and unskilled labour decline. Thus the net effect is a decline in real consumption.

- The two rural low-income groups also experience a big decline in real *per capita* consumption. These households draw a big share of their income from wages paid to rural-unskilled labour. The loss in real consumption of these two household groups is big, despite of a small decline in their nominal incomes, due to the smallest decline in their consumer price indices. Among all commodities, the biggest decline is in the price of electricity (-0.87), but the rural low-income groups spend proportionally less on electricity than any other groups.
- Among the 14 types of household, only the two rural high-income groups enjoy an increase in real *per capita* consumption.

Table 6.19 Projected Effects on Real *per Capita* Consumption of Removing User-discriminating Taxes on Electricity
(percentage change)

	(1)	(2)	(3)	(4)	(5)
			Large-Scale	Small-Scale	
Change in Power of Implicit Tax on:	Agriculture 36.0	Households 83.0	Manufacturing -36.0	Manufacturing -25.0	Services -29.0
<i>Self-employed</i>					
Rural-low-income	-0.14	-0.34	0.30	0.36	0.12
Urban-low-income	-0.05	-0.63	0.18	0.08	0.11
Rural-middle-income	-0.05	-0.03	0.00	0.07	0.10
Urban-middle-income	-0.06	-0.85	0.10	0.06	0.13
Rural-high-income	0.06	0.04	-0.15	-0.19	0.01
Urban-high-income	-0.05	-0.67	0.11	-0.05	0.14
<i>Employed</i>					
Rural-low-income	-0.14	-0.32	0.29	0.36	0.12
Urban-low-income	-0.05	-0.64	0.19	0.08	0.11
Rural-middle-income	-0.15	-0.99	0.62	0.39	0.20
Urban-middle-income	-0.17	-1.67	0.89	0.42	0.36
Rural-high-income	0.03	-0.04	-0.11	-0.12	-0.01
Urban-high-income	-0.05	-0.65	0.25	0.10	0.16
<i>Others</i>					
Rural	-0.04	-0.16	0.07	0.08	0.07
Urban	-0.06	-0.75	0.14	0.07	0.14

4.2 Effects of Removing Subsidy on Electricity Sales to Household - SIM4b

In Table 6.18, column 2 reports the simulation results of removing the subsidy on sales of electricity to households. We increase the power of user-discriminating tax on electricity sales to households by 83 per cent. As a result, the price of electricity for households increases by 75 per cent, and decreases by

8 per cent for all other user groups. Electricity production declines by 2.2 per cent.

The changes in electricity prices increase total indirect tax revenue by 4.5 per cent and real private consumption declines by 0.4 per cent. This contraction in the domestic absorption reduces the CPI by a 0.86 per cent and the GDP deflator by 1.1 per cent. The trade balance improves by Rs 1.6 billion. The net effect is an increase of 0.06 per cent in real GDP. As shown in Table 6.18, we observe that the pattern of changes in sectoral output in SIM4a is similar to that in SIM4b, except that in the latter:

- there is a decline in output of the refinery industry; and
- there is an increase in output of the agricultural, small-scale manufacturing and service sectors.

These differences are mainly due to the difference in the prices of electricity for the agriculture sector in the two simulations and its effects on the traded-goods industries. In SIM4b, along with other industries, the price of electricity declines for the agricultural industries, too. Most of the exports and import-competing industries buy intermediate inputs from the agricultural industries. The decline in electricity price for these industries reduces the production costs of exports to a big extent and there is an expansion in their demand. The net effect is an increase in the output of the agricultural sector and the fertiliser industry. Further, the decrease in the price of electricity for the agriculture sector induces substitution away from light diesel oil to electricity. The decline in the output of the refinery industry is mainly caused by the high reduction in demand for light diesel oil and furnace oil. As shown in Table 6.18, a higher reduction in electricity production causes a reduction in the output of the natural gas and oil & gas industries. The industry-level results show that output of most the non-traded goods industries in the small-scale and the services sectors declines. However, these reductions in output are outweighed by the increase in the outputs of two export industries in these sectors.

The industry-level results show decline in output of all industries except export industries and their major intermediate-inputs supplying industries.

Labour demand for, and the real wages of, all four types of labour decline since most of the export industries are not labour intensive. Further the biggest decline in output of the electricity sector which is highly labour intensive- in particular it employs a bigger portion of rural skilled labour relative to urban-skilled labour. Therefore, we observe the biggest decline in real wages of rural-skilled labour. The demand for labour in most of the export industries is for urban-unskilled labour and, therefore, the decline in real wage for this category is smallest.

In Table 6.19, column 2 shows the effects on real *per capita* consumption for the 14 types of household in SIM4b. The pattern of these effects is discussed below.

- Real *per capita* consumption declines for all the 14 types of household except for one rural-high income group.
- Most of the rural household groups experiences relatively lower decline in real *per capita* consumption compared to their counterparts in the urban region. Though the real wages of rural labour decline more than the urban wages in each category (see Table 6.18), but due to the smaller shares of electricity in their expenditures, the consumer price indices for these groups decline more than the price indices for the urban household groups. The share of electricity in total expenditure for rural households is lower than the share for urban households in each category.
- The urban-middle income group, in the employed category, experiences the biggest decline in real *per capita* consumption due to the decline in real wages of skilled labour along with the higher increase in their consumer price indices. This group draws income from both skilled and unskilled labours and spends relatively spend a bigger share of their expenditure on electricity.
- The second biggest decline is in real *per capita* consumption for the rural-middle-income group, in the employed category, which falls by 0.99 per cent. These households suffer loss in income due to the decline in real wages of skilled and un-skilled labour. The loss in their consumption,

however, is smaller due to the smaller share of electricity in their expenditure relative to their counter parts.

- The two urban-low income groups also suffer a bigger reduction (-0.63 and -0.64) in real *per capita* consumption compared to their counter parts in the rural region due to relatively higher share of electricity in their expenditure.

6.7.3 Effects of Removing the Tax on Electricity Sales to the Large-Scale Manufacturing Sector-SIM4c

In Table 6.18 column 3 shows the impact of removing user-discriminating tax on electricity sales to the large-scale manufacturing industries. A 36 per cent decrease in the power of the tax on these industries decreases the price of electricity for these industries by 29 per cent, and increases the price for all other users by 6.7 per cent. The production of electricity increases by 1.7 per cent.

The reduction in the tax on electricity sales to the large-scale manufacturing industries reduces indirect tax revenue by 2.4 per cent and increases real private consumption by 0.21 per cent. The rise in the domestic absorption increases the CPI and GDP deflator by 0.9 per cent and it deteriorates the balance of trade by Rs. 0.4 billion.

The results, at industry level, show that production in most of the industries increases, including some of the export industries. In this closure there are thirteen industries for which exports are determined endogenously. For seven, out of these thirteen industries, the increase in the production costs is curtailed by the decline in the price of electricity for the large-scale manufacturing industries. As a result, the export demand component in their sales does not decline. The output of the remaining six export industries falls. Four of these industries experience an increase in their production costs despite of the reduction in the price of electricity due to the small shares of electricity in their production costs. The other two export industries (with endogenously determined exports) are the small-scale rice husking industry and the air-transport industry. These industries face increase in the price of electricity along with other production costs, and as a result their output decline.

In Table 6.18, column 3 shows the effects on output of industries on sectoral basis. The decline in the output of the agriculture sector is due to a decline in the output of rice industry which supplies input to the two rice-husking industries. The output of the large-scale rice husking industry rises but that of the small-scale industry declines. The net effect is a reduction in rice production. Due to the increase in domestic absorption and expansion in some export industries, the output of the large-scale manufacturing sector increases. Output of all small-scale manufacturing industries and the service industries increase except for the two export industries in these sectors (small-scale-rice-husking and air- transportation). The reduction in output of these industries causes decline in aggregate sectoral production of the small-scale and services sector.

Table 6.18 shows that the real wages for all four types of labour increase as output of most of the traded and non-traded industries increases. Since most of the services industries have high intensity of skilled labour, real wage for skilled labour (1.25 per cent) in the two regions is higher than the increase in real wage for rural-unskilled labour (0.3 per cent) and for urban-unskilled labour (0.4 per cent). The unskilled labours have higher share in the labour demand of the agriculture and the large-scale manufacturing industries.

The effect on real *per capita* consumption for households is reported in column 3 of Table 6.19. The main effects are summarised below.

- Real *per capita* consumption increases for most of the household groups. Among the 14 types of household, only the two rural high-income groups experience a decline in real consumption. This is mainly caused by the small share of wages in their income. Thus their income does not increase as real wages rise but their consumer price indices rise due to the higher share of electricity in their expenditure.
- The urban middle-income group, in the employed category, enjoys the highest increase in real *per capita* consumption (0.89 per cent) due to the highest increase in real wages of skilled labour. The increase in income of this group outweighs the increase in its CPI. The counterpart of this group,

in the rural region, enjoys the second-biggest increase of 0.62 per cent in real *per capita* consumption though the rise in real wage of skilled labour is about the same in the two regions. The relatively smaller increase in real wage of rural-unskilled labour explains this difference in the benefits. Only the middle-income groups, from the employed categories, receive labour income from wages of both skilled and unskilled labours. The rest of the groups receive labour income from only unskilled labour. Therefore for the middle income group in a region, the difference in the incomes of households from self-employed and employed groups is explained by the difference in the average-wages of the skilled and unskilled labour for the region. Further, these differences in income of the self-employed and employed groups in a region explain the differences in real consumption since the expenditure patterns of these groups are similar.

- The rural low-income groups in the two employment categories experience a higher increase in real *per capita* consumption compared to their counterparts in the urban region. This difference is mainly due to the lower share of electricity in rural household consumption and the resulting smaller increase in their consumer price indices.

6.7.4 Effects of Removing the Tax on Electricity Sales to the Small-Scale Manufacturing Sector-SIM4d

In Table 6.18, column 4 shows the effects of a 25 per cent reduction in the power of the tax on electricity sales to the small-scale manufacturing industries. As a result of this reform, the price of electricity declines by 21.9 per cent for these industries and it increases by 3.1 per cent for all other users.

A comparison of columns 3 and 4 of Table 6.18 (the effects of removing taxes from electricity sales to the large-scale and small-scale manufacturing industries) shows that the increase in real private consumption is the same in the two cases (0.21) but the increase in real GDP is much smaller when the tax is removed from electricity sales to the small-scale manufacturing industries. This is mainly explained by the difference in the effect of these tax reforms on exports.

As discussed in Subsection 6.7.3, output of seven major export industries increases due to the high electricity share in their production costs when the tax rate on electricity supplied to the large-scale industries is removed. Contrary to this, only one of the major export industries (rice husking) is in the small-scale manufacturing sector. Therefore, when the tax on electricity sales to the small-scale manufacturing industries declines, only one export industry enjoys a fall in the price of electricity and subsequent expansion in exports. Further, the increase in the price of electricity for other export industries (which are mainly in the large-scale manufacturing sector) reduces the demands for their exports. As shown in columns 3 and 4 of Table 6.18, there is a bigger deterioration in the trade balance, which declines by Rs 0.44 billion when the price of electricity for small-scale manufacturing industries declines.

The decline in exports and increases in imports is apparent in changes in sectoral output shown in column 4. The outputs of all sectors increase except the output of the large-scale manufacturing sector and the refinery industry, which fall by 0.29 per cent and 0.03 per cent respectively. The former sector comprises of the major exports and import-competing industries. In the refinery industry, the decline in output is mainly caused by the reduction in the demand for furnace oil and other petroleum product. The major users of furnace oil are electricity industries and some small-scale manufacturing industries. The small-scale manufacturing industries substitute furnace oil by electricity whose price has declined sharply for these industries. Thus, this decline in the demand for furnace oil outweighs the increase in its demand from electricity industries. The reduction in the demand for other petroleum product is due to the contraction in air-transport industry; an other export industry with endogenously determined exports. The competitiveness of this industry declines due to the rise in domestic prices and labour wages.

The effects on real *per capita* consumption of households in SIM4d are reported in column 4 of Table 6.19. We give a summary of these effects below.

- Real *per capita* consumption increases for most of the household groups. It declines only for the two rural-high income groups and one urban-high-income group.
- The urban middle-income group, in the employed category, enjoys the biggest increase in real *per capita* consumption, being 0.42 per cent. Its counter part in the rural region enjoys the second biggest increase (0.39 per cent).
- The two rural-low-income groups, in the employed and self-employed categories, also enjoy a big increase in real *per capita* consumption which increases by 0.36 per cent.

As discussed in the previous sections, these differences in the effects on real *per capita* consumption of households are mainly caused by the differences in income of households, the shares of electricity in their consumption, and changes in the number of households in each group. As shown in column 4 of Table 6.18, real wages of all four types of labour increase in SIM4d. Increases in the wages are relatively higher for rural labours compared to the urban labour. This difference is bigger in the wages for unskilled labours. All these differences are mainly explained by the employment pattern of the four labour categories in industries and the changes in output of these industries.

Our detailed results show that there is a smaller increase in the consumer price indices for most of the rural-household groups due the smaller shares of electricity in their expenditures. Thus most of the rural-household groups enjoy bigger increase in real income, and thus in real consumption. The higher real wages in rural areas induce migration of households from urban to the rural region. Thus the benefit of higher increase in real consumption of the rural groups is reduced on *per capita* basis to an extent as the number of households in the rural region increases. Real *per capita* consumption for the two rural-high-income declines for two reasons. First, these households have highest shares of electricity in their expenditures compared to the other rural groups. Second, these households are not benefited by the increase in the wages as, labour-wage income has a small share in their income.

6.7.5 Effects of Removing Tax on Electricity Sales to the Service Industries -SIM4e

The last column in Table 6.18 shows the effects of a 29 per cent decline in the power of the tax on electricity sales to the service industries. This reduction in the taxes reduces the price of electricity for these industries by 28.6 per cent, and increases the price of electricity by 0.40 per cent for all other users.

The effects of reducing electricity price for the service industries are smaller relative to those of removing the tax on electricity sales to the manufacturing industries. Only one of the major export industries is in this sector and the rest are non-traded goods industries. A reduction in the price of electricity for this sector benefits the non-traded goods industries and only on traded good industry enjoys this reduction in the price of electricity. All the other traded goods industries lose their competitiveness due to increase in the production cost. As sectoral-output results show, there is a decline in the production of all sectors except the small-scale manufacturing and service sectors which produce non-traded goods.

Most of the non-traded goods industries have much higher labour intensity compared to the manufacturing industries. Among these industries, the services industries have relatively higher intensity of the skilled labour compared to the unskilled labour. Expansion in the services industries increases wage for skilled labour more than the wage for unskilled labour. Further, the contraction in the low-labour intensive industries (traded-goods industries) do not displace many labours. As a result for all four types of labour, the increase in real wage is smaller in SIM4e compared to SIM4d (see column 5 of Table 6.18). The differences between the wages of the rural-unskilled and urban-unskilled are also smaller compared to the differences in SIM4c and SIM4d; in which the user-discriminating taxes on the large-scale and small-scale industries are removed.

In SIM4e the removal of the tax on electricity sales reduces the aggregate demand for electricity; unlike SIM4c and SIM4d in which the aggregate electricity demand increases when we remove taxes on electricity sales to the two manufacturing sectors. We notice that in SIM4e output of only the small-scale

and services sectors increase. The demand for electricity from the small-scale manufacturing industries falls, despite of the expansion in their output, due to substitution of electricity for other fuels as electricity price rise for these industries. Therefore, there is an increase in electricity demand from only the services industries. The share of these industries in the total electricity demand is 18 per cent. Increase in the demand for electricity from the services industries are outweighed by the decline in its demand from all other users. Therefore electricity production declines by 0.05 per cent.

The last column in Table 6.20 shows the effect on real *per capita* consumption in SIM4e. There is an increase in the consumption for all groups except one rural-high-income group. There are two noticeable features of these results. First, increase in real *per capita* consumption for the two middle-income-employed groups (rural and urban) is much higher compared to the other 11 groups that also enjoy increase in the consumption. This is caused by the higher increase in real wages of skilled labour which belong to this group only. All the other household groups endow only unskilled labour. Thus a small difference in real wages of unskilled labour in the two regions results in a smaller difference in the effects on real consumption between the rural and urban households in most of the groups. Further, the increase in electricity price for households is also very small and, therefore, the effects due to variations in the expenditure pattern are also small.

6.7.6 Cumulative Effects of Removing User-discriminating Taxes on Electricity Sales- SIM4

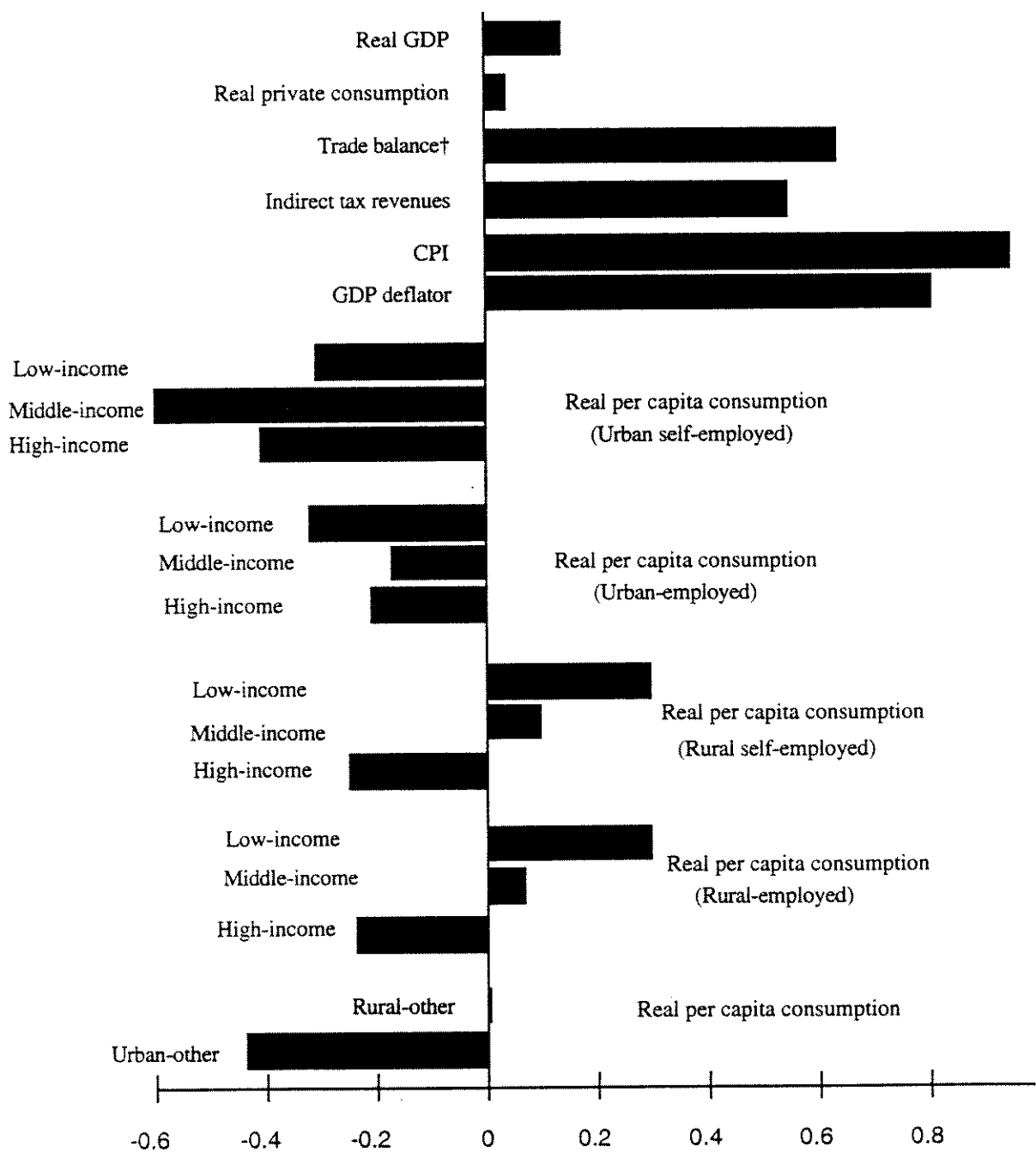
In this section we discuss the cumulative effects of removing all the user-discriminating taxes on electricity sales. Figure 6.3 shows selected macro-economic effects and the effects on real *per capita* consumption for all 14 types of household.

As discussed, on average there is no tax on electricity sales. Hence, the shocks given to the taxes in SIM4 are computed to remove all taxes and subsidies on electricity sales. Nevertheless, the cumulative effect is a 0.55 per cent

increase in total indirect tax revenues. The loss in indirect tax revenue due to the removal of taxes on the electricity sales, to the manufacturing and service industries, is less than the revenues generated by removing the subsidies on electricity sales to households and the agriculture sector (see Table 6.18). Removal of the discrimination in taxes against the manufacturing sectors improves the competitiveness of seven of the major export industries which are relatively more electricity intensive and import-competing industries. On the other hand, removal of subsidies on electricity sales to households contracts the non-traded goods industries which are highly labour intensive. The re-allocation in electricity consumption of sectors relocates labour from non-trade goods industries to the traded goods industries with small increase in real wages as the latter type of industries is not labour intensive. As a result, real GDP increases which increases real private consumption. The balance of trade improves by Rs 0.64 billion.

Aggregate household real consumption increases by 0.04 per cent, but this is not enjoyed by all income groups. Figure 6.3 shows that all seven urban income groups experience a decline in real *per capita* consumption. The highest negative effect is on the consumption of the urban-middle-income group, in the self-employed category, that experiences a 0.60 per cent decline in real *per capita* consumption. The two urban-low-income groups experience about 0.30 per cent fall in real *per capita* consumption.

Figure 6.3 Cumulative Effects of Tax Reforms in Electricity Prices (SIM4)



† Rs Billion

As shown in Figure 6.3, only the two high-income groups experience a loss in real *per capita* consumption in the rural region when all other groups enjoy an increase in the consumption. Among the rural groups, the highest increase in real *per capita* consumption (about 0.30 per cent) is enjoyed by the

two low-income groups. The second highest increase is experienced by the rural middle-income group in the self-employed category that enjoys a 0.10 per cent increase in the consumption.

The differences in real *per capita* consumption for households by income and region are mainly caused by the differences in the consumption patterns of these households. The consumption pattern of households shows that the share of electricity in total expenditure of the urban households is higher than that of rural households in all categories. For example the electricity share in the expenditure of the urban low-income group is 1.5 per cent compared to its 0.2 per cent share in expenditure of the rural low-income group. In the rural region the share of electricity increases with income and thus the highest income group has the highest share of electricity expenditure. In contrast, for urban households the middle-income group has the highest share of electricity expenditure (1.6 per cent) and the highest income group has the smallest share (1.3 per cent). Thus increase in the consumer price indices for most of the rural groups are much smaller than the increase in consumer price indices for the urban groups when the price of electricity rises.

Our detailed results show that there is an increase in real wages for rural labour in most of the income groups when nominal wages are deflated by the consumer price indices of these groups. Thus real wage for the rural households increases due to the differences in the consumer price indices. The migration results show that the number of households increases in the rural region in all the income groups. Real income of households, and their consumption, increases in all the rural groups, except for the households in the two high-income groups, due to higher wages and increases in number of households. As discussed, the two high income groups have higher share of electricity in their expenditure and have smaller share in of labour wages in their income relative to other income groups. Thus rise in electricity price increases their consumer price indices while increase in wages does not put much affects on their income. The net effect is a decline in real consumption for these two categories.

Among the urban groups, real *per capita* consumption for all urban groups declines. The biggest decline is in the consumption for the middle-income group in the self-employed category due to the smaller increase in nominal wages of urban-unskilled labour relative to skilled labour and the highest share of electricity in their consumption. In the urban-employed category which owns both skilled and unskilled labour, the higher increase in the wages of skilled labour balances out the increase in the CPI to an extent therefor this group suffers a smaller loss in real consumption.

In brief, Figure 6.3 shows that there is an increase in real *per capita* consumption for most of the rural groups and decline in the consumption of all the urban groups when the user-discriminating taxes on electricity are abolished. Conversely it implies that these distortions in electricity prices favour all the urban groups at the expense of the low- and middle-income groups of the rural region.

6.8 Effects of Revenue-Neutral Reforms on User-discriminating Taxes on Electricity-SIM4N

In Table 6.20, column 1 contains the cumulative effects of removing user-discriminating taxes on electricity (SIM4) and column 2 shows the cumulative effects of these reforms in a revenue-neutral environment (SIM4N). Column 3 shows the difference between SIM4 and SIM4N. In the following paragraphs, we discuss the results of SIM4N.

Column 1 in Table 6.20 shows that total indirect tax revenues increases by 0.55 per cent when user-discriminating taxes on electricity are abolished. A decrease of 0.05 per cent in the power of indirect taxes on all commodities balances out this surplus. The cumulative effect of these taxes is an increase of 0.12 per cent in real private consumption. As a result, the balance of trade improves by Rs 0.42 billion compared to Rs 0.64 billions in SIM4. Similarly, there is a higher increase in the CPI (1.14 per cent) and the GDP deflator relative to SIM4; when all the user-discriminating taxes on electricity are removed with a surplus in the indirect tax revenues.

Column 2 in Table 6.20 shows that in SIM4N, outputs of all non-energy sectors rise. Output of the energy sectors (electricity, natural gas, and oil & gas industries) decline between -0.17 and -0.43 per cent. The industry-level results show that most of the export industries in the large-scale manufacturing sector experience a higher increase in their outputs relative to all other industries. The price of electricity for the large-scale manufacturing industries declines by 36 per cent as the net effect of all the tax reform. These industries, such as the cotton-fabrics industry, have production processes that are relatively more electricity intensive. Similarly, some of the electricity intensive import-competing industries (such as the other chemical and fertiliser industries) also enjoy a reduction in their production costs due to the lower electricity price for the large-scale manufacturing industries. There is increase in output of the small-scale manufacturing and services industries. Output of these non-traded industries increases mainly due to the increase in real private consumption. In the agriculture sector, most industries experience increases in the demands for their products from the domestic and export markets. However, some of the import-competing industries in this sector (such as oil seed and pulses industries) becomes less competitive and reduces their output as electricity price for the agriculture sector increases along with an increase in labour wages. Though the demands for electricity by the manufacturing and service industries increase, the net effect on electricity demand is negative because of the reduction in the demand from households. The electricity sector has the highest share (18 per cent) in total demand for natural gas. The decline in electricity production reduces the demand for natural gas. As a result we observe a decline in output of the natural gas and oil & gas industries.

The changes in the demand and production pattern affect the real wages of labour. The employment pattern of labour shows that industries in the services sector, small-scale manufacturing and agriculture sector are labour intensive. The services sector employs the biggest share of all the 4 types of labour. Increase in output of the services sector put positive effects on real wages of all 4 types of labour. Nevertheless, in the rest of the sectors, the 4 types of labour are not

uniformly dispersed. This generates differences in the wages of the 4 types of labour. We deflate the nominal wages by the overall CPI to derive real wages. Increase in real wage of urban-skilled labour is higher relative to the wage of rural-skilled. This is caused by the higher expansion in output of large-scale manufacturing industries relative to output of the agriculture sector. The large-scale manufacturing industries employ only urban labour and 88 per cent of these labours are unskilled. In contrast to this, the agriculture sector employs mainly rural labour and about 95 per cent of which are rural-unskilled labour. The Rural-skilled labours are mainly employed in the services and energy sector. Their share in the labour force of the electricity sector is double than the share of urban-skilled labour. Thus there is a decline in real wage of rural-skilled labour when output of the electricity sector declines. The demand for urban-skilled labour also decline with the reduction in electricity generation but it is compensated by the increase in their demand from other sector; in particular from the large-scale manufacturing sector.

Column 3 in Table 6.20 shows the effect of a 0.05 per cent uniform reduction in the power of tax on all commodities. This reduction in the taxes increases the positive effects of removing user-discriminating taxes on electricity. There is an additional increase of 0.01 percentage point in real GDP and of 0.08 percentage point increase in real private consumption. As discussed, removing of the user-discriminating taxes on electricity improves the balance of trade. An additional uniform reduction in the power of tax on all commodities reduces this gain by 0.22 percentage point but does not wipe it out completely.

Table 6.20 Cumulative Effects of Revenue-Neutral Reforms in User-discriminating Taxes on Electricity
(percentage change)

Cumulative effects in:	(1) SIM4	(2) SIM4N	(3) = (2) - (1)
Real GDP	0.14	0.15	0.01
Real private consumption	0.04	0.12	0.08
Trade balance [†]	0.64	0.42	-0.22
Indirect tax revenue	0.55	0.00	-0.55
Uniform tax rate	0.00	-0.05	-0.05
CPI	0.95	1.14	0.19
GDP deflator	0.81	1.02	0.30
<i>Real Wages</i>			
Rural-skilled	-0.19	-0.14	0.05
Urban-skilled	0.70	0.90	0.20
Rural-unskilled	-0.04	0.04	0.08
Urban-unskilled	0.53	0.63	0.10
<i>Sectoral Output</i>			
Agriculture	0.17	0.17	0.00
Oil & gas	-0.17	-0.17	0.00
Large-scale manufacturing	0.66	0.63	-0.03
Small-scale manufacturing	0.21	0.23	0.02
Services	0.14	0.15	0.01
Fertiliser	1.60	1.59	-0.01
Refinery	0.02	0.02	0.00
Cement	0.00	0.00	0.00
Natural gas	-0.43	-0.43	0.00
Electricity	-0.24	-0.27	0.03

[†] Rs Billion

Table 6.21 shows the effect on real *per capita* consumption of 14 types of household in SIM4 and SIM4N. These results are summarised below.

- In the urban region, real *per capita* consumption of all 7 types of household decline between -0.01 and -0.53 per cent. The highest decline is experienced by the middle-income group in the self-employed category.
- In the rural region, the low- and middle-income groups, in both the employment categories, enjoys increase in real *per capita* consumption between 0.15 and 0.38 per cent. The highest increase is experienced by the two low-income groups.
- The two high-income groups in the rural region experience a decline in real *per capita* consumption of a 0.25 per cent.

Column 3 in Table 6.21 shows that most of the income groups are benefited when the user-discriminating electricity tax reforms are made revenue-neutral. The income groups that experience a negative effect on real *per capita* consumption in SIM4 experience a lower decline in the consumption in SIM4N and the rest of the groups enjoy higher increase in the consumption.

Column 1 in Table 6.20 shows that real wages for rural labours decline, for skilled and unskilled labour. These real wages are nominal wages deflated by the over all CPI. Our detailed results shows that when the nominal wage for a labour type is deflated by the CPI for each income group, the real wage for rural households rises for all income groups due to the smaller increase in their consumer price indices relative to the urban groups. We notice migration of households from the urban to the rural region in all income groups. The number of rural households increases by 12 and 11 per cent for the low and middle income groups, in the two employment categories. As a result, the group income of the rural households increases more than the income of urban household groups. Though these benefits are reduced on *per capita* basis to some extent but, the net effects are increase in real *per capita* income, and consumption, of most of the rural households.

Table 6.21 Cumulative Effects on Real *per Capita* Consumption in SIM4 and SIM4N
(percentage change)

Household Type	(1) SIM4	(2) SIM4N	(3) = (2) - (1)
<i>Self-employed</i>			
Rural-low-income	0.30	0.38	0.08
Urban-low-income	-0.31	-0.26	0.05
Rural-middle-income	0.10	0.15	0.05
Urban-middle-income	-0.60	-0.53	0.07
Rural-high-income	-0.25	-0.25	0.00
Urban-high-income	-0.41	-0.34	0.07
<i>Employed</i>			
Rural-low-income	0.30	0.38	0.08
Urban-low-income	-0.32	-0.26	0.06
Rural-middle-income	0.07	0.17	0.10
Urban-middle-income	-0.17	-0.01	0.16
Rural-high-income	-0.24	-0.25	-0.02
Urban-high-income	-0.21	-0.12	0.09
<i>Others</i>			
Rural	0.01	0.05	0.04
Urban	-0.44	-0.37	0.07

6.9 Effects of Removing User-discriminating Taxes on Natural Gas Sales

Our discussion on natural gas prices in Chapter 2 shows that there are user-discriminating taxes on natural gas sales to four major consumer categories. In this section we discuss the effects of removing these user-discriminating taxes. Table 6.22 shows the power of taxes on natural gas for four consumer categories and the hypothetical percentage changes in them. Because on the average, there is no tax on natural gas, the hypothetical changes in the power of taxes are calculated to abolish the taxes and subsidies. According to Table 6.22,

the power of the tax on natural gas sales to the manufacturing and service industries should be decreased by 11 and 38 per cent respectively, and the power of tax on natural gas sales to household should be decreased by 8 per cent. There should be a 38 per cent increase in the power of the tax on natural gas sales to the electricity industries. We simulate the effects of these hypothetical changes in SIM5a to SIM5d. In the following sub-sections, we discuss separately the effects of removing tax (subsidy) to each consumer category, then go on to a discussion on the cumulative effect of these tax reforms.

Table 6.22 Values for Exogenous Power of User-discriminating Taxes on Natural Gas Sales

User Category	<i>Ad valorem</i>	Percentage Change in Power of Tax†
	Power of Tax in the Base Year	
Manufacturing	1.12	-11.0
Services	1.62	-38.0
Electricity Industries	0.77	29.0
Households	1.09	-8.0

† These shocks are given in SIM5a - SIM5d, SIM5 and SIM5N to the user-discriminating tax variables for natural gas.

6.9.1 Effects of Removing User-discriminating Tax on Natural Gas Sales to the Manufacturing Industries-SIM5a

An 11 per cent reduction in the power of the tax on natural gas sales to the manufacturing industries, both small- and large-scale, has no effect on real GDP. However, real private consumption increases by 0.03 per cent. There is a negative effect on the balance of trade that declines by Rs 70 million. Similarly, total indirect tax revenue declines by 0.55 per cent.

The increase in domestic absorption due to reduction in the tax has positive effect on domestic prices; the CPI rises by 0.10 per cent and the GDP deflator rises by 0.09 per cent. Because the total labour supply is fixed, for skilled and unskilled labour, the rise in domestic absorption increases labour wages. Table 6.23 shows that real wages for all the four labour categories

increase except for the rural-unskilled labour category. The rural- and urban-skilled labour categories experience an increase of a 0.13 and a 0.11 per cent in real wages respectively. A smaller increase in real wage of rural-unskilled labour (0.03 per cent) and a decline of 0.01 per cent in real wages for urban-unskilled labour is caused by a contraction in the export industries. Major shares of all the 4 types of labour are employed in the service industries. However, apart from these industries, the large-scale manufacturing industries employ a significant share of urban-unskilled labour and the agricultural industries employ rural-unskilled labour. Further, the large-scale manufacturing industries have high intensity of urban-unskilled labour (92 per cent of labour employed by these industries is urban-unskilled labour) and the agricultural industries have high intensity of rural-unskilled labour (97 per cent of labour employed by these industries is rural-unskilled labour). Most of the major export industries belong to the large-scale manufacturing sector and their raw-material is supplied by the agricultural industries. The industry-level results show that the rise in domestic prices causes a decline in the demand for all major export industries except for three industries in which natural gas has one to two per cent shares in total costs. Output of these industries rises between 0.02 and 0.09 per cent. However, there is a decline in the output of the other eight major export industries. As a net result we see a 0.02 per cent increase in the output of the large-scale manufacturing sector and a zero change in the output of the agricultural sector.

An 11 per cent reduction in the power of the tax on natural gas sales to the manufacturing industries and the subsequent increase in its production increases the price of natural gas for all other users by 5.84 per cent and reduces its price for the manufacturing industries by 5.16. In GE-PAK, the production structures of the manufacturing industries allow substitution between natural gas and electricity. The decline in the price of natural gas for the manufacturing industries along with the increase in the price of electricity, due to higher natural gas prices for it, induces substitution of electricity by natural gas. Hence at sectoral level, we notice that the output of the electricity industries falls by 0.11 per cent.

6.9.2 Effects of Removing User-discriminating Tax on Natural Gas Sales to the Service Industries-SIM5b

Table 6.23 shows that there is an increase of 0.01 per cent in real GDP when user-discriminating tax is removed from natural gas sales to the service industries. Real private consumption increases by 0.09 per cent. There is a negative effect on the balance of trade that declines by Rs. 280 million. Indirect tax revenue declines by 0.71 per cent.

The rise in domestic absorption increases domestic prices; the CPI rises by 0.25 per cent and the GDP deflator goes up by 0.28 per cent. There are changes in the pattern of sectoral production and real wages of 4 types of labour. The model projects an increase in real wages for all the four labour categories. Output of all the export industries, and their related industries, decline due to rising domestic prices, while the non-traded goods industries enjoy expansion due to increase in the domestic absorption. As a net effect, we observe a negative effect on the output of the agricultural and large-scale manufacturing sectors and a positive effect on the output of the small-scale manufacturing and services sectors. Output of energy industries declines between .01 to .04 per cent.

Unlike SIM5a, reduction in the price of natural gas in SIM5b does not increase its total consumption. The detailed results show that natural gas consumption in the service sector increases by 0.09 per cent when the price of natural gas for this sector declines. Natural gas consumption increases by 0.14 per cent in the small-scale manufacturing industries and by 0.02 per cent in the cement industry. However, there is a reduction in natural gas consumption of the electricity industries (-0.05 per cent), the large-scale manufacturing industries (-0.05 per cent) and the fertiliser industry (-0.06 per cent). These industries have a major share in the demand for natural gas. Therefore, as a net effect, we observe a small (-0.01 per cent) decline in natural gas consumption.

Table 6.23 Effects of Reforms in User-discriminating Taxes on Natural Gas

	(1)	(2)	(3)	(4)
	SIM5a	SIM5b	SIM5c	SIM5d
	Manufac- turing Industries	Service Industries	Electricity Industries	Households
Power of Implicit Tax on:	-11.0	-38.0	30.0	-8.0
Real GDP	0.00	0.01	-0.00	0.00
Real private consumption	0.03	0.09	-0.07	0.01
Trade balance [†]	-0.07	-0.28	0.18	-0.03
Indirect taxes	-0.55	-0.71	0.39	-0.06
CPI	0.10	0.25	-0.25	0.02
GDP deflator	0.09	0.28	-0.29	0.02
<i>Real Wages</i>				
Rural-skilled	0.11	0.26	-0.33	0.03
Urban-skilled	0.13	0.33	-0.28	0.01
Rural-unskilled	-0.01	0.09	-0.11	0.02
Urban-unskilled	0.03	0.14	-0.05	-0.00
<i>Sectoral Output</i>				
Agriculture	0.00	-0.02	0.01	-0.00
Oil & Gas	0.24	-0.01	-0.16	0.01
Large-scale manufacturing	0.02	-0.04	0.04	-0.01
Small-scale manufacturing	0.00	0.03	-0.02	0.00
Services	0.01	0.02	0.00	0.00
Fertiliser	0.39	-0.04	0.24	-0.03
Refinery	0.00	-0.02	0.15	0.00
Cement	0.00	0.00	-0.00	0.00
Natural gas	0.66	-0.01	-0.44	0.03
Electricity	-0.11	-0.04	-0.27	-0.00

† Rs Billion

6.9.3 Effects of Removing User-discriminating Tax on Natural Gas Sales to the Electricity Industries-SIM5c

Removing of user-discriminating subsidy on natural gas sales to the electricity industries have no effect on real GDP. As shown in column 3 of Table 6.23, however, there is a decline of 0.07 per cent in real private consumption.

This decrease in domestic absorption improves the balance of trade by Rs 180 million and increases total indirect tax revenues by 0.39 per cent. Domestic prices decline; the CPI goes down by 0.25 per cent and the GDP deflator declines by 0.29 per cent.

The reduction in domestic absorption reduces domestic prices while there is an expansion in the output of the export and the import-competing industries. As shown in column 3 of Table 6.23, there is a 0.04 per cent increase in the output of the large-scale manufacturing sector and a 0.01 per cent increase in the output of the agriculture sector. Among the non-traded goods industries the output of the small-scale manufacturing sector declines by 0.02 per cent. All the energy industries also experience a reduction in output. The highest reduction is in the output of the natural gas industry (-0.44). The electricity industries experience a 0.27 per decline.

As shown in Table 6.23, there is a decline in real wages of all the 4 types of labour. The increase in labour demand by the export industries is outweighed by a reduction in labour demand by the non-traded goods industries. A higher reduction in real wage of skilled labour is due to its higher share in the natural gas and the electricity industries.

6.9.4 Effects of Removing User-discriminating Tax on Natural Gas Sales to Households-SIM5d

The last column in Table 6.23 shows the effects of removing user-discriminating tax on natural gas sales to households. There is no effect on real GDP, and the real private consumption increases by 0.01 per cent. Total indirect tax revenue declines by 0.06 per cent and the balance of trade deteriorates by Rs 30 million.

Real wages of all 4 labour categories rise except the wage of urban-unskilled labour which remains unchanged. This is caused by a decline in output of large-scale manufacturing industries. There is a small increase in the output of the two energy industries, *i.e.*, natural gas (0.03 per cent increase) and oil & gas

industries (0.01 per cent increase). The production of most of the sectors remains unchanged.

6.9.5 Cumulative Effect of Removing User-discriminating Taxes on Natural Gas Sales-SIM5

Figure 6.4 shows the cumulative effects of removing all user-discriminating taxes on natural gas sales. Real GDP increases by 0.01 per cent, and real private consumption rises by 0.06 per cent. A loss of 0.94 per cent in total indirect tax revenue, and of Rs 190 million in the balance of trade, occurs as a result of removing all user-discriminating taxes and the subsidies on natural gas sales. There are increases in domestic prices, CPI increases by 0.12 per cent and the GDP deflator rises by 0.10 per cent. Figure 6.4 shows that all income groups enjoy a rise in real *per capita* consumption, except the rural high-income group, in the employed category.

There are two noticeable changes in household real *per capita* consumption of 14 types of household.

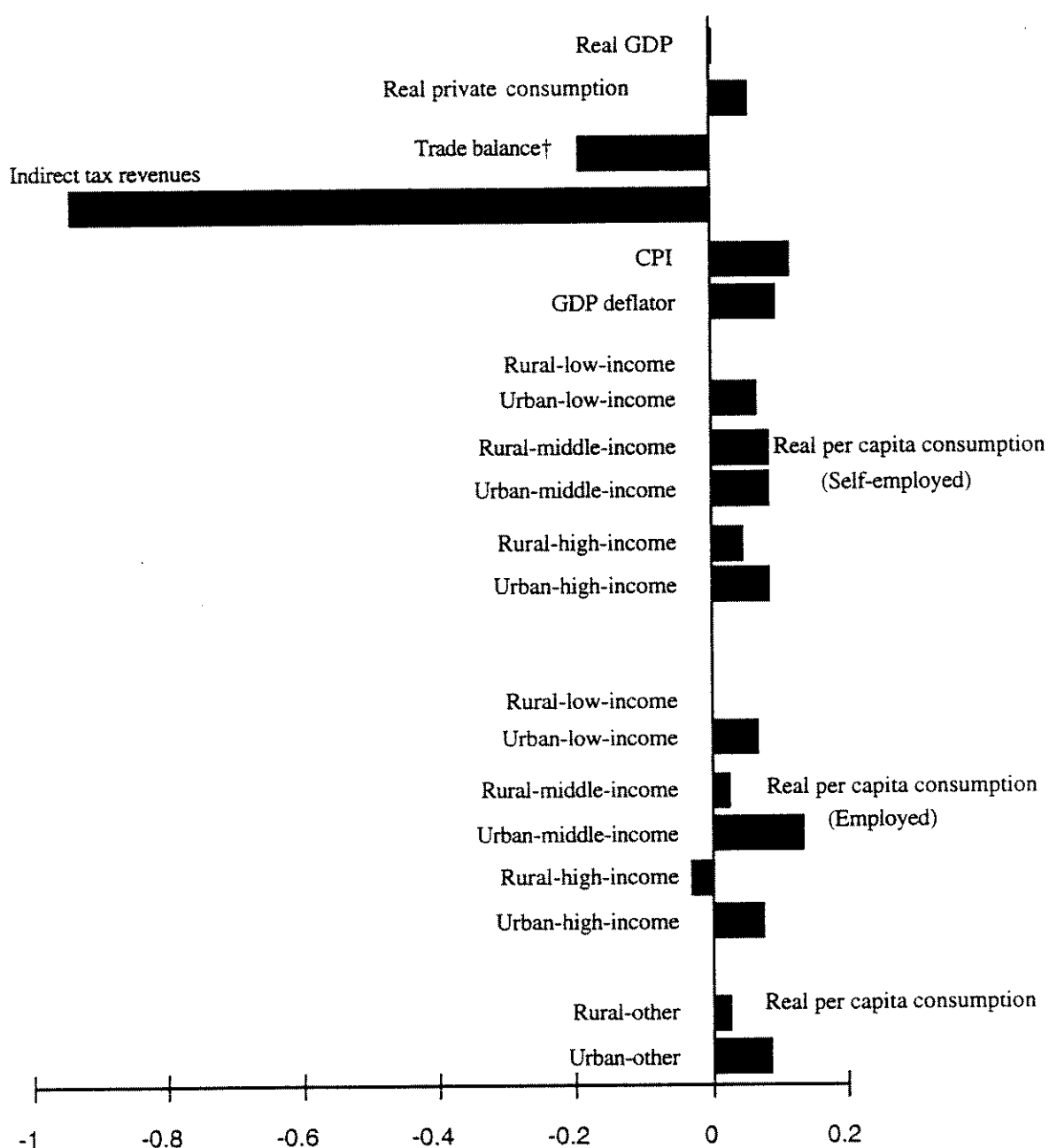
- In most of the household types, the urban groups enjoy a higher increase in real *per capita* consumption compared to their counterparts in the rural region.
- Among the 7 types of urban household, the middle-income groups from the two employment categories enjoy highest increase in real *per capita* consumption compared to all other groups.
- A different pattern of changes in real *per capita* emerges for rural households. The consumption for the two low-income groups remains unchanged while the two rural-middle income groups enjoy an increase in real *per capita* consumption. Only one high-income group enjoys an increase in real *per capita* consumption while the other group experiences a decline in the consumption.

These results show that removing of user-discriminating taxes on natural gas benefits urban-households more than the rural households and benefits households in the middle-income group more than the other two income groups,

in both the regions. Out of 14 household groups, the three rural groups are net losers.

Results of SIM5 show that removing all taxes and subsidies on natural gas reduces real wage of rural-unskilled labour and increase the wage of urban-unskilled labour. In the skilled category, real wage of urban labour increases more than the wage of rural labour. The consumer price indices by household groups show that there is a smaller increase in the CPI for rural households compared to urban household in each group. As a net effect, the real wages for rural households in all income groups are lower than the wages of the urban groups. This induces migration of household from the rural region to the urban region in all income groups. At the group level, there is a smaller increase in the income and consumption of the rural households in all income groups. The detailed results show that the CPI for rural households increases by 0.11 per cent for all income groups. Thus variation in real income, and thus of consumption, across the rural household groups is mainly caused by their dependence on unskilled labour wages.

Figure 6.4 Cumulative Effects of Tax Reforms in Natural Gas Prices (SIM5)



† Rs Billion

6.10 Cumulative Effects of Revenue-Neutral Reforms in User-discriminating Taxes on Natural Gas -SIM5N

In SIM5 we simulate the effects of removing user-discriminating taxes on natural gas sales to the four user categories. In SIM5N, we repeat the same experiment in a revenue-neutral environment. Table 6.24 reports the results of SIM5 and SIM5N. The following paragraphs discuss the results of SIM5N.

A uniform 0.08 per cent increase in the power of indirect tax rate on all commodities makes up the loss incurred in total indirect tax revenues due to the reforms in taxes on natural gas. The net effects of all the tax reforms are zero per cent change in real GDP, and a decline of -0.07 percent in real private consumption. There is a positive effect on the trade balance; it improves by Rs 180 million.

The reduction in real private consumption reduces domestic prices; the CPI declines by 0.22 per cent and the GDP deflator goes down by 0.25 per cent. The pattern of sectoral production also changes. The output of all sectors increases except the output of the small-scale manufacturing sector (-0.01) and the electricity industries (-0.39). The output of energy industries, other than the electricity industries, rises. Output of the natural gas industry increases by 0.25 per cent. The changes in production and consumption pattern affect real wages of all the 4 labour categories. Real wages of all 4 types of labour decline. The decline in real wage of urban unskilled labour is smaller (-0.05) compared to the decline in real wages of other three categories; which decline between 0.15 and 0.23 per cent. This difference is mainly caused by a high increase in the demand for urban unskilled labour from the large-scale manufacturing industries, the refinery and the fertiliser industries; these industries have high share of urban-unskilled labour in their total labour demand.

Table 6.24 Cumulative Effects of Revenue-Neutral Reforms in User-discriminating Taxes on Natural Gas

	(1) SIM5	(2) SIM5N	(3) = (2) - (1)
Real GDP	0.01	0.00	-0.01
Real private consumption	0.06	-0.07	-0.13
Trade balance [†]	-0.19	0.18	0.37
Indirect taxes	-0.94	0.0	
Uniform indirect tax rate	-	0.08	
CPI	0.12	-0.22	-0.34
GDP deflator	0.10	-0.25	-0.35
<i>Real Wages</i>			
Rural-skilled	0.07	-0.23	-0.30
Urban-skilled	0.19	-0.15	-0.34
Rural-unskilled	-0.01	-0.16	-0.15
Urban-unskilled	0.12	-0.05	-0.17
<i>Sectoral Output</i>			
Agriculture	-0.01	-0.00	0.01
Oil & Gas	0.08	0.09	0.01
Large-scale manufacturing	0.01	0.07	0.06
Small-scale manufacturing	0.02	-0.01	-0.03
Services	0.03	0.01	-0.02
Fertiliser	0.56	0.58	0.02
Refinery	0.15	0.14	-0.01
Cement	0.00	0.00	0.0
Natural gas	0.24	0.25	0.01
Electricity	-0.43	-0.39	0.04

[†] Rs Billion

Table 6.25 shows the effects on household real *per capita* consumption by income, region and employment category in SIM5 and SIM5N. The results of SIM5N are summarised below.

- In contrast to SIM5, Real *per capita* consumption for all 14 types of household decline, except for one rural-high income group. The highest decline is in the consumption for the rural middle-income group, in the employed category. Real consumption of this group declines by 0.15 per cent.
- The two rural low-income groups experience the second highest decline in real *per capita* consumption, *i.e.* -0.14 per cent. This decline in the consumption is much higher compared to a 0.03 per cent decline in real consumption for the two urban low-income groups.
- In the rural self-employed category, the high-income group enjoys a 0.05 per cent increase in real *per capita* consumption.

In brief, removal of user-discriminating taxes on sales of natural gas put higher adverse effects on most of rural-low income groups. As shown in Table 6.25, the negative effects of removing these taxes on rural household vary between -0.15 and -0.01 per cent. These variations in negative impacts on households' consumption conversely show two things. First, the user-discriminating taxes favour rural households more than the urban households. Second, these tax discriminations have income distributional effects only among rural households, as they favour more low-income groups. In contrast, among urban household groups, these taxes favour middle- and high-income groups more than the low-income groups in the employed category, while they favour all the income groups in the self-employed category.

Table 6.25 Cumulative Effects on Household Real *per Capita* Consumption in SIM5 and SIM5N (percentage change)

Household Type	(1) SIM5	(2) SIM5N	(3) = (2) - (1)
<i>Self-employed</i>			
Rural-low-income	-0.00	-0.14	-0.12
Urban-low-income	0.07	-0.03	-0.12
Rural-middle-income	0.09	-0.01	-0.09
Urban-middle-income	0.09	-0.03	-0.15
Rural-high-income	0.05	0.05	0.02
Urban-high-income	0.09	-0.03	-0.14
<i>Employed</i>			
Rural-low-income	-0.00	-0.14	-0.12
Urban-low-income	0.07	-0.03	-0.12
Rural-middle-income	0.03	-0.15	-0.16
Urban-middle-income	0.14	-0.09	-0.25
Rural-high-income	-0.03	-0.01	0.04
Urban-high-income	0.08	-0.06	-0.16
<i>Others</i>			
Rural	0.03	-0.04	-0.05
Urban	0.09	-0.04	-0.15

6.11 Elasticity of Social Welfare Cost with respect to Indirect Tax Revenues-SIM6

As discussed in Chapter 1, Pakistan like other developing countries, relies heavily on indirect taxes to raise revenues and to change the income distribution. Our discussion of the effects of abolishing discrimination in taxes on energy products shows that these reforms have positive effects on aggregate private consumption but give negative distributional effects across income groups and regions. For example the tax reforms for petroleum products increases real *per capita* consumption for the middle- and high-income groups but reduces real *per*

capita consumption for low-income groups. A simple weighted-average of these effects is an increase in private consumption. A vast literature in public economics addresses the issue of the marginal social cost of taxes or the marginal cost of public funds. Some of these analyses incorporate distributional effects and have various types of household while others focus on the aggregate welfare effect and assume a single household type. For Pakistan, Ahmad and Stern (1990) computed the marginal cost in terms of social welfare of raising an extra unit of revenue through increase in the tax on the *i*th commodity which is defined as

$$\lambda_i = \frac{\partial V / \partial t_i}{\partial R / \partial t_i}, \quad (6.11.1)$$

$$\frac{\partial V}{\partial t_i} = - \sum_h \beta^h x_i^h \quad (6.11.2)$$

where *V* represents a welfare function, x_i^h is the demand for commodity *i* by household *h* and β^h are the welfare weights. The variable *R* is total indirect tax revenues while *t* is the tax rate on commodity *i*. The concept of λ_i has been extensively used by Ahmad and Stern in their work on tax reforms. If $\lambda_i > \lambda_j$, then one increases welfare by switching a marginal unit of revenue from good *i* to good *j*, keeping overall revenue constant. The welfare weight β^h represents the social marginal utility of income for household *h* and its value depends on judgements. Ahmad and Stern computed these welfare-weighted marginal cost measures, l_i , for a set of consumer goods assuming three alternative values of β^h . The consumer goods are ranked according to the value λ_i to exhibit the direction of tax reforms¹. The major weakness of this analysis is that it is carried out in a partial equilibrium framework and, hence, holds households' income and producers' prices constant. Panda and Sarkar used changes in real GDP and overall price as a criterion to rank two alternative scenarios of raising the indirect tax revenues. They used their CGE model for India to simulate the macro

¹ A substantial theoretical and empirical literature focus on the issues of tax reforms in the developing countries. For example Ahmed and Stern (1984, 1986, 1990), Newbry and Stern (1986), Stern (1990).

economic effects of raising government revenues through two alternatives: (i) by increasing prices in the administered price sector which includes all energy industries and railways, and (ii) by increasing indirect tax rate on non-administered price sector prices. According to their study the indirect tax rate scenario turned out to be the best as the increase in GDP is highest and price rise is lowest. Using the same criterion the study found that, among the administered prices, price of petroleum products and coal are better instruments than the price of railway or electricity.

GE-PAK computes elasticities of social welfare cost with respect to public funds (SWC) while social welfare cost is measured by a set of social welfare functions. In SIM6 we simulate a 1 per cent increase in the power of tax of each commodity individually to compute elasticities of social welfare (SWC) with respect to indirect tax revenue. In the following paragraphs, we briefly discuss the concept of social marginal cost of government revenue, the social welfare functions and their application in the recent work in public economics. We then describe our definition of the elasticity of social welfare cost of indirect tax revenues and the social welfare function used to compute these elasticities. In Subsection 6.11.1 we present the ranking of commodities according to their social welfare cost elasticities with respect to public fund.

Ballard, Shoven and Whalley (1985)² developed a multi sectoral, dynamic CGE model of the US economy to calculate the marginal excess burden per additional dollar of tax revenue. They estimated the incremental welfare costs of raising extra revenues from an already existing distorted taxes. In a recent work Ballard and Medema (1993) has computed the marginal cost of public funds in a CGE model of the US economy that incorporates pollution externalities and abatement technologies explicitly. Ballard *et al.* (1993) has defined the marginal cost of public funds (MCF) as

² The subject of marginal welfare costs of taxes have been discussed in many studies; Stuart (1984), Hanson and Stuart (1985), Browning (1976).

$$MCF = \frac{\text{Change in Consumer Welfare}}{\text{Change in Total Indirect Tax Revenues}}, \quad (6.11.3)$$

where the change in consumer welfare is estimated for a single representative consumer by the equivalent variation. Ballard *et al* computed the marginal cost of raising public funds by levying pollution taxes and subsidies (Pigovian tax).

A limitation of the above definition is that it does not take into account the distributional effects resulting from any proposed change in the taxes to generate the public funds. Therefore, a social welfare function is required that aggregate the welfare of multiple consumers considering the distributional effects. A variety of functions have been applied in social welfare analysis of reforms in the public policy. For example in a recent work, Fortin and Truchon (1993) have applied a set of social welfare functions to compare and rank various negative income taxes and workfare schemes in a simulation model of a small open economy. These functions are based on a family of the social welfare function first proposed by Atkinson (1970) and followed by many others³. The popular social welfare measure of Atkinson is an index that incorporates distributional concerns in the aggregation of individuals' utilities⁴.

In our model we have defined the elasticity of social welfare cost with respects to public funds as

$$SWC = - \frac{\% \text{change in social welfare}}{\% \text{change in Indirect tax revenue}} \quad (6.11.4)$$

where the social welfare is measured by a welfare function of type "Mean of order τ ", that was proposed by Atkinson (1970) and also applied by Fortin *et al.* (1993). The function is defined as:

$$W(\text{PERCONR}_1, \dots, \text{PERCONR}_{\text{POP}}) = \left(\frac{1}{\text{POP}} \sum_{i=1}^{\text{POP}} \text{PERCONR}_i^{\tau} \right)^{\frac{1}{\tau}}, \quad \tau \leq 1 \text{ and } \tau \neq 0, \quad (6.11.5)$$

³ Roberts (1980a), Blackorby and Donaldson (1978), and Jorgenson and Slesnick (1984).

⁴ Diewert (1985) has discussed, at length, a variety of social welfare functions and their properties.

where $PERCONR_i$ is real consumption of individual i and POP is total population. When $\tau = 1$, the function turns out to be a utilitarian function. As τ decreases and becomes negative more importance is given to the welfare of the poor and less to the welfare of the rich. When τ tends towards minus infinity, the function tends toward $\min \{PERCONR_1, \dots, PERCONR_{POP}\}$, i.e. the Rawlsian welfare function (Rawls, 1971). One may interpret τ as the Atkinson inequality aversion parameter. Its value depends either on judgements or can be inferred from government policies such as personal income tax structure⁵.

In our model there are 14 types of household; households are categorised by region and income group. Thus our welfare function in equation (6.11.5) becomes

$$W^\tau = \sum_{r \in REG} \sum_{n \in INC} \frac{POP_m}{POP} PERCONR_m^\tau \quad \text{if } \tau \leq 1 \text{ and } \tau \neq 0, \quad (6.11.6)$$

and using L' Hôpital's rule:

$$W = \prod_{r \in REG} \prod_{n \in INC} PERCONR_m^{\left(\frac{POP_m}{POP}\right)} \quad \text{if } \tau = 0. \quad (6.11.6a)$$

where $PERCONR_m$ is real *per capita* consumption in group n in the region r . POP_m is the population of that group, and POP is total population. Equation (6.11.6) can be written as:

$$W^\tau = \sum_{r \in REG} \sum_{n \in INC} S_m PERCONR_m^\tau \quad \text{if } \tau \leq 1 \text{ and } \tau \neq 0, \quad (6.11.7)$$

and

$$\ln(W) = \sum_{r \in REG} \sum_{n \in INC} S_m \ln(PERCONR_m) \quad \tau = 0, \quad (6.11.7a)$$

where S_m is defined as:

$$S_m = \frac{POP_m}{POP}, \quad r \in REG, n \in INC \quad (6.11.8)$$

⁵ For example Piggott (1982) estimated the elasticity of the social marginal valuation of income to derive welfare weights for different individuals in different income groups for Australia.

$$POP_m = Q_m \times HSIZE_m, \quad r \in REG, n \in INC. \quad (6.11.9)$$

HSIZE is the household size of the group m and Q is the number of households in this group. In linear percentage change form, equation (6.11.7) becomes

$$\tau \times w = \sum_{r \in REG} \sum_{n \in INC} \frac{S_m PERCONR_m^\tau}{\sum_{r \in REG} \sum_{n \in INC} S_m PERCONR_m^\tau} (s_m + \tau \times perconr_m),$$

$$\tau \leq 1 \text{ and } \tau \neq 0, \quad (6.11.10)$$

$$w = \sum_{r \in REG} \sum_{n \in INC} (S_m \times [\text{perconr}_m + \ln(PERCONR_m) \times s_m]),$$

$$\tau = 0. \quad (6.11.10a)$$

Following our notational system discussed in Chapter 4, the variables in the above equations are in the lower-case and represent percentage change while coefficients are in upper-case and represent data flows in the base year (see Table B1 in Appendix B for conversion rules). Hence, perconr_m , and s_m represent percentage change in real *per capita* consumption and population-share of group m respectively while w represents percentage change in the social welfare.

By taking linear percentage form of equation (6.11.8), we arrive at

$$s_m = q_m + \text{hsize}_m - \text{pop}. \quad (6.11.11)$$

The percentage changes in total population and household size, *i.e.* hsize_m and pop , are zero since total population is assumed exogenously fixed and the household size does not change in a policy simulation. Therefore, we can replace s_m in equation (6.11.10) by q_m using equation (6.11.11). Equation (6.11.10) can now be written as:

$$\left(\sum_{r \in REG} \sum_{n \in INC} S_m PERCONR_m^\tau \right) \times w = \sum_{r \in REG} \sum_{n \in INC} S_m PERCONR_m^\tau$$

$$\times \left(\text{perconr}_m + \frac{q_m}{\tau} \right).$$

$$\tau \leq 1 \text{ and } \tau \neq 0, \quad (6.11.12)$$

$$w = \sum_{r \in REG} \sum_{n \in INC} (S_m \times [\text{perconr}_m + \ln(PERCONR_m) \times q_m]),$$

$$\tau = 0. \quad (6.11.12a)$$

In the following two steps we transform the population weights, s_m , given in the above function into consumption weights. Since total consumption in a group, $VITEM\_k_m$ in the base year is

$$VITEM\_k_m = POP_m \times PERCONR_m, \quad r \in REG, n \in INC \quad (6.11.13)$$

therefore,

$$POP_m = \frac{VITEM\_k_m}{PERCONR_m}, \quad r \in REG, n \in INC \quad (6.11.14)$$

We replace the population variables in our welfare function in equation (6.11.10) using equation (6.11.14) to arrive at

$$\left(\sum_{r \in REG} \sum_{n \in INC} VITEM\_k_m \times PERCONR_m^{\tau-1} \right) \times w = \sum_{r \in REG} \sum_{n \in INC} VITEM\_k_m \times PERCONR_m^{\tau-1} \times \left(perconr_m + \frac{q_m}{\tau} \right), \quad \tau \leq 1 \text{ and } \tau \neq 0, \quad (6.11.15)$$

$$\left(\sum_{r \in REG} \sum_{n \in INC} \frac{VITEM\_k_m}{PERCONR_m} \right) \times w = \sum_{r \in REG} \sum_{n \in INC} \left(\frac{VITEM\_k_m}{PERCONR_m} \times \left[perconr_m + \ln(PERCONR_m) \times q_m \right] \right), \quad \tau = 0. \quad (6.11.15a)$$

Thus the change in the social welfare in our model is computed by

$$w = \sum_{r \in REG} \sum_{n \in INC} X_m \left(perconr_m + \frac{q_m}{\tau} \right), \quad \text{if } \tau \leq 1 \text{ and } \tau \neq 0 \quad (6.11.16)$$

where

$$X_m = \frac{VITEM\_k_m \times PERCONR_m^{(\tau-1)}}{\sum_{r \in REG} \sum_{n \in INC} VITEM\_k_m \times PERCONR_m^{(\tau-1)}}$$

We then define the elasticity of social welfare cost with respect to indirect tax revenue as follows:

$$SWC = - \frac{w_{\tau}}{torev - xigdp}, \quad (6.11.17)$$

where $torev$ and $xigdp$ are the percentage change in total indirect tax revenue and the GDP deflator respectively. Since we have defined our welfare function on real

consumption, we deflate the tax revenue, which is in nominal terms, by the GDP deflator in the above equation. In our study we have computed the social welfare cost of 1 per cent increase in the power of indirect tax on each commodity separately for $\tau = 1$, and -1 ; these are our judgement values. Hence $SWC_{\tau i}$ is the elasticity of social welfare cost with respect to indirect tax revenue when there is one per cent increase in the power of tax on commodity i for the given value of Atkinson's inequality parameter τ . Table 6.26 shows the implication of assuming different values of τ .

Table 6.26 Welfare Functions

Atkinson Inequality parameter Welfare Function		
(τ)	Type	Implication
1	Utilitarian	A dollar increase in real consumption has equal weight for all persons.
0	Relativist	1 % increase in real consumption for a rich person is equal to 1 % increase for a poor person.
-1	Mean of order 1	A one per cent increase in real consumption for a low-income person has higher weight than a one per cent increase in consumption for a higher-income person. The value of the weight is a function of <i>per capita</i> consumption of the group in the base year.
$-\infty$	Rawlsian	$\text{Min}\{\text{perconr}_{r1}, \dots, \text{perconr}_m\}$

Before proceeding to our results, it is worthwhile to summarise the environment in which the welfare cost elasticities are computed.

- In our model government income is composed of indirect tax revenues, direct tax revenues and returns to capital and land owned by the government. There is a change in the government income from all sources when tax rate on commodity i is increased by one per cent. However, we only consider indirect tax revenue because it has the biggest share in government income.

- The government expenditure includes purchase of commodities and some transfers to households. We assume that the government expenditure on commodities is fixed in real terms. However, its transfer to households changes with changes in its total income but these payments are not made to compensate the loss in income of households due to the increase in indirect tax.
- Changes in government income or private savings do not effect the investment expenditure which is assumed to be constant in real terms.

Thus in this experiment we increase distorted indirect tax on each commodity to reduce the already given trade deficit.

6.11.1 Ranking of Energy Products According to their Social Welfare Cost Elasticities (SWC) -Case A

Table 6.27 gives names of energy products, their SWC values, and their ranks among 8 energy products. Columns 1 and 3 give the SWC values for two values of inequality-aversion parameter; $\tau = 1, -1$. We refer them respectively as case A and B of SIM6. Case A assume that there is no inequality aversion in computation of welfare and a dollar decrease in real *per capita* consumption, at the margin, has equal weights for all groups irrespective of their consumption level in the base year. Column 1 ranks energy products according to their social welfare cost elasticities, SWC, in the descending order for Case A while column 3 reports the SWC values for these products in case B which gives higher weights to changes in real consumption of the lower-income groups. For example column 1 shows that the value of SWC for high speed diesel (0.13) is highest among all the energy products in case A. This ranking changes as we assume $\tau = -1$. Column 4 shows that kerosene has the highest value of SWC in case B. Column 5 shows change in the rank of a product in Case A relative to its rank in Case B. For example, the rank of high speed diesel is 1 in Case A and it slides down to 2 in Case B. Column 5 shows a decline by unity in the rank of high speed diesel. In this subsection we analyse the ranking of energy products according to their elasticities of welfare costs and changes in their rankings in two cases. In our analysis we focus on two aspects:

- what are the energy products that have high costs of public revenues in terms of welfare cost? and
- How much does the ranking of these products change when we change the level of inequality aversion (' τ ' value) ?

Table 6.27 Ranking of Energy Products according to Elasticities of Social Welfare Costs (SWC)

Case A: $\tau = 1$			Case B: $\tau = -1$			
(1)	(2)		(3)	(4)	(5)	
						= (2) - (4)
<u>Commodity Name</u>	<u>SWC</u>	<u>Rank</u>	<u>Commodity Name</u>	<u>SWC</u>	<u>Rank</u>	<u>Change in the Rank</u>
High speed diesel	0.13	1	High speed diesel	0.13	2	-1
Kerosene	0.13	2	Kerosene	0.17	1	+1
Gasoline	0.12	3	Gasoline	0.11	4	-1
Light speed diesel	0.11	4	Light speed diesel	0.13	3	+1
Other petroleum products	0.09	5	Other petroleum products	0.10	5	0
Furnace oil	0.09	6	Furnace oil	0.08	6	0
Electricity	0.07	7	Electricity	0.08	7	0
Natural Gas	0.07	8	Natural Gas	0.06	8	0

From the ranking of energy products in case A, we notice the following points.

- The social welfare cost elasticities for natural gas and electricity are about the same and are the lowest among 8 energy products.
- Among the petroleum products, the social welfare cost elasticities for high speed diesel and kerosene are highest and are about the same. The elasticity value is higher for gasoline compared to its values for light diesel oil, furnace oil and other petroleum products.

Thus among the energy products, natural gas and electricity are better candidates for indirect-tax revenue collection as one per cent increase in taxes on these commodities will give smallest decline in the social welfare. In the previous sections we discussed in detail the mechanism through which changes

in taxes on these products affect real consumption of households. Another factor in computation of these elasticities is effect of the tax increase on indirect tax revenues and the GDP deflator.

Column 1 in Table 6.28 shows increase in total indirect tax revenue when the power of the sales tax on an energy product is increased by one per cent. Column 2 contains the resulting decline in the GDP deflator induced by the decline in the domestic absorption when we increase tax revenue. Column 3 contains the indirect tax revenue deflated by the GDP deflator.

Table 6.28 Percentage Changes in Indirect Tax Revenues and the GDP deflator
SIM6

Energy Product	(1) Tax Revenues t0rev	(2) GDP deflator xigdp	(3) = (1) - (2) Real Indirect Tax Revenues
Light speed diesel	0.005	-0.002	0.01
Furnace oil	0.03	-0.01	0.04
Kerosene	0.04	-0.02	0.06
Other petroleum products	0.06	-0.05	0.11
Gasoline	0.08	-0.04	0.12
Natural gas	0.09	-0.03	0.12
Electricity	0.21	-0.10	0.31
High speed diesel	0.22	-0.11	0.33

Table 6.28 ranks energy products in ascending order of real indirect tax revenues. Column 3 shows that there is a big variation in real indirect tax revenues generated by increasing taxes on these products. Column 1 shows that one per cent increase in taxes on high speed diesel and electricity increases the tax revenue to the same extent. Similarly these increases in taxes on these two products reduce the GDP deflator to the same extent. Contrary to this, the increase in the tax revenues is much smaller when taxes on other energy products such as kerosene and furnace oil are increased. Column 3 shows that increases in taxes on high speed diesel and electricity give biggest increase in real indirect tax

revenues. Thus high speed diesel and electricity are the best candidate if revenue generation is the main objective.

There are many factors that cause variations in the tax revenues and the GDP deflator reported in Table 6.28. The effects on the tax revenues and the GDP deflator, due to an increase in the tax on a commodity, depend on various factors such as the share of the commodity in the domestic absorption, share of imports in its supply, substitution possibility in its use in the industries, share of the commodity in the marginal budgets of households, and labour intensity in its production. For example, a tax increase on a commodity that have high share in the domestic absorption generates higher revenues. Similarly a tax increase on a commodity that have smaller labour intensity induces a smaller decline in labour wages and consequently smaller decline in income of households which rely mainly on labour wages. Results in Table 6.28 show that tax increases on high speed diesel and electricity generate highest real indirect tax revenues. Tax increases on natural gas, gasoline and other petroleum product generate a much smaller increase in real tax revenues. Our base-year data shows that the ranking of the energy products according to their sales values are very similar to the ranking given in Column 3. Thus taxes on high speed diesel and electricity give biggest increase in the revenue due to their biggest size of sales.

The ranking of energy products changes when the social welfare cost of per unit of the revenue is considered (see Table 6.27). High speed diesel becomes the most undesirable good to increase tax revenues due to the biggest decline in the social welfare when tax on it is increased. As discussed in Section 6.3.1, high speed diesel is used in the road transport industry (one of the major margin industries). Increase in its price increases the price of all the commodities. Contrary to this, the shares of electricity (an intermediate input) are smaller in costs of the industries. Our detailed results show that the social welfare cost of electricity is second biggest among energy products. However, electricity becomes a better candidate due to higher increase in tax revenues relative to other energy products when taxes on these products are increased.

Similarly, natural gas becomes a better candidate to generate revenue, relative to electricity, due to its smaller negative impact on social welfare. Significant shares of electricity and natural gas are used in household consumption. However, the shares of natural gas in expenditures of 14 types of household are much smaller than the shares of electricity. Thus the negative effects on household expenditures are higher relative to the effects of natural gas when prices of electricity and natural gas are increased.

Social Welfare Cost Elasticities incorporating Distributional Effects: Case B

Column 4 in Table 6.28 shows that the ranking of the energy products changes when value of the inequality parameter (τ) is changed to -1. As shown in equation (6.11.16) that a lower value of τ gives a smaller weight to the change in real *per capita* consumption of the middle- and high-income groups. In the base-year data, real *per capita* consumption for the middle-income groups is about twice the consumption of the low-income groups in the two regions. This difference is bigger for the high-income groups. Real *per capita* consumption for the high-income group in the rural region is 7 times of the consumption for the low-income groups. In the urban region, it is about 10 times of the consumption for the low-income group. Thus in SIM6 for $\tau = -1$, the weight given to change in real *per capita* consumption is 0.5 for the two middle-income groups and it is 0.14 for consumption of the rural-high-income group.

There are three noticeable changes in the ranking of energy products in case B, when we take into account the distributional effects, which are discussed below.

- The elasticity of welfare cost turns out highest for kerosene among all energy products when we give higher weights to the decline in real consumption of the low income groups. The shares of kerosene are higher in expenditure of the low-income groups while the shares of gasoline are higher in expenditure of the middle- and high-income groups. This is the

major reason for increase in SWC value for kerosene and a decline in its value for gasoline.

- The SWC values change for electricity and natural gas, however, these products remain the best candidates for increasing indirect tax revenues.
- The SWC value increases for electricity in case B while it decreases for natural gas. Thus tax on electricity has more distributional effects relative to natural gas. This is mainly explained by the differences in the consumption pattern of electricity and natural gas for the 14 household groups. Our database shows that the shares of natural gas are smallest relative to electricity in expenditure of all 14 types of household. Further these shares are smaller for the low-income groups relative to the middle- and high-income group in each region and the employment categories. Therefore, the lower weights to middle- and high income groups result in the smaller decline in the social welfare cost of increasing tax on natural gas.

We have contained our discussion on the elasticities of social welfare cost of public funds to energy products. A similar analysis can be done for all other commodities. However, there is one limitation of this ranking procedure if investment goods are also included in the set of commodities. As discussed, real investments are fixed in the short-run closure, therefore, increase in tax on investment goods do not affect the demand for these commodities which results in a big increase in tax revenues. The real consumption *per capita* is not affected very much because it does not include future consumption. The elasticities of the social welfare cost of investment goods will be smallest in ranking. There are many ways to solve this problem. For example we can change the closure in the short-run to assume exogenously fixed balance of trade, or balance of payment, and endogenously determined real investment. However, these estimates can best be made in an inter-temporal model that takes into account the general equilibrium effects in both the short- and long-term.

Chapter 7

Concluding Remarks

7.1 Introduction

The first objective of this thesis was to construct a multisector general equilibrium model of energy-economy interaction in Pakistan. We developed such a model, GE-PAK, which incorporates the key structural characteristics of Pakistan's economy, and treats energy production and consumption in detail. The second objective of the thesis was the analysis of energy pricing policy in Pakistan. This involved estimation of distortions in energy prices and evaluation of the effects of removing these distortions. We reviewed the pricing of three major commercial energy products: petroleum products, electricity, and natural gas and estimated distortions in their prices. These products have major shares in the demand for commercial energy and their prices are regulated by the government. We distinguished three types of tax on these products; source-discriminating, product-discriminating, and user-discriminating. Some of these taxes are explicit while others are implicit. We estimated source- and commodity-discriminating tax rates for five petroleum products, user-discriminating tax rates on electricity sales to the five major user categories, and user-discriminating tax rates on natural gas sales to the four major consumer categories. The government's objectives in these tax discriminations are not documented explicitly. We inferred its objectives from the prevailing energy pricing policy. Some of these objectives are in line with the motive behind the administered pricing system. Review of the distortions in energy prices suggests that one objective of the pricing policy is equity or welfare of the low-income group. This is a general concern of the governments in most of the developing countries; it motivates an administered pricing system for some basic commodities. We apply our GE model to evaluate the effectiveness of this

pricing policy to achieve its announced objective of equity, and to evaluate the micro- and macro-economic effects caused by these distortions in energy prices. We simulated the effects of eliminating these source-, product-, and user-discriminating distortions in taxes on energy products in the short-run. Our analyses of the results focused on the income-distributional, macro-economic and sectoral effects of these reforms. This empirical application of GE-PAK shows that the model can provide extremely useful and detailed inputs for informed policy making. In this sense the relevance of our study is not confined to energy products or to Pakistan but has implications for many developing countries that face similar policy issues. We can apply the model for analysis of pricing policy of other commodities due to its detailed disaggregation of production activities, user groups and primary factors.

In this final chapter we briefly review the major findings of our simulation results, and describe the important strengths and weaknesses of our model and its applications in this thesis. Implementation and application of a CGE model require a comprehensive data base which matches the model's specification. We briefly discuss the development of the data base for GE-PAK. We also discuss some possible applications of the model, and point to implications for future research.

7.2 Major Findings

The major objective of energy pricing policy in Pakistan is equity, or the social welfare of the low-income group. Our review of taxes on energy products shows that households consistently receive a subsidy or pay the lowest tax on energy products. There are source-, product-, and user-discriminating taxes on energy products in favour of households. Energy is considered a basic necessity and these discriminating taxes are intended to counterbalance the large imbalances in the income distribution and, at the same time, to generate revenue for the government. In this study we simulated the effects of removing three types of discrimination in taxes on energy products to assess how far these discriminations meet the motive behind them. As detailed in Chapter 6, we

simulated the effects of hypothetical changes in energy taxes with revenue-neutrality conditions and without revenue-neutrality condition. In the summary below of the major findings, we report the simulation results of the revenue-neutral reforms. In both the scenarios we assume that at the margin, all prices are determined by the market forces.

Table 7.1 Summary of Results

	<u>Effects of Revenue-neutral Reforms in Taxes on</u>					
	Petroleum Products		Electricity		Natural Gas	
Real GDP	+		+		+	
Trade Balance	-		+		+	
Equity across Region & Income [†] :	<u>Rural</u>	<u>Urban</u>	<u>Rural</u>	<u>Urban</u>	<u>Rural</u>	<u>Urban</u>
Low-income	-	-	+	-	-	-
Middle-income	+	+	+	-	-	-
High-income	+	+	-	-	-	-

[†]We report the results for the self-employed category since the pattern of changes is qualitatively similar for most of the household groups.

Table 7.1 summarises three simulation results in qualitative terms. It shows that only the tax reforms for petroleum products have negative effects on real per capita consumption of low-income groups and positive effects on middle- and high-income groups. Conversely, it shows that distortions in petroleum products meet the social equity objective. Similarly, the balance of trade deteriorates only when we remove the distortions in taxes on petroleum products. This shows that this tax structure meets the objective of management of the trade balances.

Contrary to this, removing of distortions in the taxes on electricity have negative effects on real per capita consumption of all urban income groups and have positive effects on low- and middle income groups of rural households. Conversely, the discriminations in taxes on electricity are against the social equity object for the rural region. Further, this tax structure is against the equity across region as they favour the urban households against most of the rural households.

Removing tax distortions for electricity improves the balance of trade. Hence, this tax structure also does not meet the objective of the trade balance management. The tax reforms for natural gas have negative impacts on real *per capita* consumption of all household groups.

In the following paragraphs we summarise the magnitude of these effects. In the last paragraph, we summarise the result on ranking of these energy products according to the elasticity of their social welfare cost with respect to indirect tax revenues.

Effects of Revenue-neutral Reforms in Petroleum Product Taxes -SIM3N

Elimination of source- and product-discriminating taxes on all petroleum products reduces real *per capita* consumption by 0.20 per cent for the low-income groups and by 0.01 per cent for rural-low income groups. On the other hand, real consumption for the middle- and high-income groups increases between 0.01 and 0.35 per cent. In aggregate these reforms improve real consumption for society by 0.12 but with negative effects on equity. Conversely these results show that, to an extent, the discrimination in taxes on petroleum products serves the social equity objective of the energy pricing policy. These tax reforms change the sectoral composition of GDP. Output of non-traded goods industries increases. Regarding energy industries, output of natural gas and electricity industries increase by 0.05 per cent while output of the oil & gas and refinery industries declines by 0.03 and 0.13 per cent respectively. The imports of oil and petroleum products increase. The balance of trade declines by Rs 170 million. Conversely, these tax discriminations help to manage the trade balance and energy consumption. However, all the objectives are achieved at the cost of reduction in real GDP of about 0.05 per cent.

Effects of Revenue-neutral Reforms in Electricity Taxes-SIM4N

The results of SIM4N show that removing user-discriminating taxes on electricity reduces real *per capita* consumption for all the seven types of urban household between -0.01 and -0.53 per cent and by 0.25 per cent for

the two rural high-income groups. The biggest decline is in real *per capita* consumption for the urban middle-income group in the self-employed category. Contrary to this, real *per capita* consumption for the low- and middle-income groups increases between 0.15 and 0.38 in the rural region. The highest increase is in consumption for the two rural-low income groups. Conversely these results show that user-discriminating taxes on electricity do not favour all low-income groups. In general, these discriminations favour the urban groups and reduce social equity among the rural groups. Among the urban groups, these discriminations give biggest benefits to the low-income group in the employed category but give lowest benefit to them in the self-employed category. These user-discriminations cause a 0.12 per cent decline in aggregate real consumption which is mainly borne by the rural low- and middle income groups. It appears that urban-households benefit at the expanse of rural households. Results of SIM4N show that removing user-discrimination in taxes improves the balance of trade by Rs 420 millions while real GDP increases by 0.15 per cent. As far as energy demand management is concerned these reforms will reduce electricity consumption by 0.27 per cent and natural gas consumption by 0.43 per cent. Thus we can say that these discriminating taxes induce more energy consumption. Output of the refinery industry increases by 0.02 per cent.

We simulated the elimination of user-discriminating taxes on electricity in two scenarios; with revenue-neutral condition (SIM4N), and without revenue-neutral condition (SIM4). The distinguishing feature of SIM4 results is the increase in indirect tax revenue when the user-discriminating taxes on electricity prices are eliminated. There is a 0.14 per cent increase in real GDP and a 0.04 per cent increase in real private consumption. The balance of trade improves by Rs 640 million. All these positive effects are mainly caused by the decline in the tax on electricity for manufacturing industries. In particular some of the export industries that are electricity intensive enjoy cost reductions and increase their exports. The pattern of

changes in real *per capita* consumption by household type, discussed above, remains unchanged in the two simulations. In SIM4N there is a 0.05 per cent reduction in the power of taxes on all commodities. Conversely it shows that these user-discrimination in taxes are causing losses in indirect tax revenue. The reduction in tax rate in SIM4N has positive effects on most of the income groups which enlarge the positive effects on their real *per capita* consumption.

Effects of Revenue-neutral Reforms in Natural gas Taxes-SIM5N

Elimination of user-discriminating taxes on natural gas reduces real *per capita* consumption for most types of household but to different extents. Only the rural high-income group in the self-employed category experiences an increase in the consumption. Relatively higher reduction is experienced by rural households in most of the groups; in particular the two low-income groups and a middle-income. Their real *per capita* consumption decline by 0.14 per cent while the consumption of their urban counterparts declines by 0.03 per cent. We can draw two conclusions: (i) user-discriminating taxes on natural gas favours the rural low- and middle-income groups, (ii) these discriminations benefit urban groups uniformly in the self-employed category and benefit the low-income group to the smallest extent. At macro level, there is no effect on real GDP while the balance of trade improves by Rs 180 million. The CPI and the GDP deflator decline by 0.22 and 0.25 per cent respectively. Results of SIM5 show that the reforms for taxes on natural gas without the revenue-neutrality condition have positive effects on all types of households but cause a loss of 0.94 per cent in indirect tax revenue and a move towards deficit of Rs 190 million.

Ranking of Energy Products according to Elasticity of Social Welfare cost with respect to Public Funds-SIM6

Our simulation results show that distributional effects of eliminating discrimination in energy taxes vary across products. Like many other developing countries, Pakistan relies heavily on indirect taxes for the

generation of public funds. In SIM6 we computed a social welfare index for each energy product when the tax rate on a product is increased by one per cent. We used this index to compute the elasticity of social welfare cost with respect to indirect tax revenues. We used Atkinson's welfare function of "Mean of order τ " to compute the social welfare cost where τ represents the degree of inequality aversion. We ranked the energy products in descending order of their elasticities of social welfare cost (SWC) for two values of τ . In case A, $\tau = 1$ and the decline in real *per capita* consumption for all groups are given equal weights irrespective of the income disparities in the base year. In case B $\tau = -1$ and the weight given to the decline in real *per capita* consumption for a group varies inversely to its consumption level in the base year. The higher is *per capita* consumption for a group in the base year, the lower weight is given to consumption change for it. Results of Case A show the ranking of energy products for social welfare cost if we are not concerned with the equity issue in levying indirect taxes. We draw two conclusions from case A results: (i) The elasticities of social welfare costs (SWC) of imposing tax on high speed diesel and kerosene are highest among energy products, and are of the same magnitude. Thus one per cent increase in revenue through taxing either high speed diesel or kerosene reduces social welfare by the same extent. Our ranking of all commodities according to SWC shows that these two petroleum products fall in the first decile of commodities which have highest values of SWC. (ii) The elasticities for natural gas and electricity are lowest among energy products and even among all the commodities. The values of SWC for these two energy products are about the same and they fall among the commodities with lowest values of SWC. Hence these two products are better candidates to increase indirect tax revenue. Results of case B show that the equity concern changes the ranking of commodities. We notice two things in these results:

(i) Kerosene stands out highest among all the energy products and even among all the commodities mainly due to its higher share in expenditure of

the low-income groups. Among energy products, though, petroleum products remain at higher ranks but they change ranks among themselves. The major switch overs are between kerosene and high speed diesel, and between gasoline and light speed diesel oil. Unlike Case A the value of SWC is much higher than its value for high speed diesel mainly because high diesel consumption is mainly in the transport sector which supply a margin good and hence the effects are distributed across all groups. Thus if equity effects are taken into account, high speed diesel is a better candidate for increasing the indirect tax revenues than kerosene. Similarly gasoline is a better candidate than light diesel oil, high speed diesel and kerosene. According to equity considerations the elasticities of social welfare cost are about the same for the two diesel products.

(ii) Natural gas stands lowest among all the energy products in case B. The ranking of natural gas and electricity does not change relative to petroleum products but their values of SWC change. In case B the value of SWC for natural gas is a bit lower than the value for electricity. Thus according to equity considerations, natural gas is a better candidate to increase indirect tax revenues than electricity. As discussed in Chapter 6, one per cent increase in electricity and natural gas taxes give smaller increase in real indirect tax revenues but they also have smaller negative effects on real consumption of households because the shares of these products are relatively smaller in expenditure of the low-income groups. The shares of natural gas are smaller than the electricity shares.

We acknowledge that there are certain limitations of this analysis and these findings are subject to certain conditions. We have discussed the limitation of the model and the study in Section 7.5. Nevertheless, this analysis serves our purpose of demonstrating that GE-PAK can be applied to provide extremely useful and detailed information on policy making. GE-PAK, similar to other CGE models, can be used in various other ways. In Sections 7.4 we briefly discuss these applications.

7.3 Major Features of the Model

Detailed Accounting of Income

Unlike many other CGE models, GE-PAK has been developed around a social accounting matrix that enables a detailed treatment of the income of 14 types of household which are categorised by region, employment category, and income group. We have specified the income of each household type from various sources such as labour wages, returns on non-corporate capital, dividends on corporate capital, remittances from abroad, and transfers from other household types and the government. The treatment of household income from dividends is simple and is defined as a linear function of the income of the corporation and its dividend rate. We have assumed a uniform dividend rate for all types of households for each corporation type.

Similarly, incomes of two types of corporation and the government are also specified in detail. This enables us to show changes in the undistributed return on capital, return on capital owned by the rest of the world in Pakistan, and income of the government from returns on capital. There is a detailed treatment of government income from various sources including indirect and direct tax revenue. We assume that each income group pays a certain fraction of their income as direct tax. Similarly, the two corporations also pay a certain fraction of their income to government as a corporate tax.

Regional Labour Market

In the model there are four types of labour that are categorised by region and within region by profession, *i.e.*, skilled and unskilled. A two-level nested labour demand function for an industry determines its labour demand by profession from a region. The top-level nest defines labour demand as a Leontief composite of rural and urban labour. However, there is a substitution possibility between skilled and unskilled labour from a region. The bottom-level nests define CES composites of skilled and unskilled labour for each of urban and rural labour categories. The aggregation of labour demand from industries gives us the total demand for skilled and unskilled labour from each region.

On the supply side, a simple inter-region migration function allows migration of households between rural and urban region in response to the change in relative wages in two regions. In this function, households in each income group, within a profession, migrate in response to change in their labour wages relative to the weighted-average of the labour wages in the two regions for that profession. Hence change in labour supply of a skill type in each region is determined by this migration function plus any exogenous shift in labour supply hours from each household group.

Modelling of Electricity Industries and Energy Inputs Demand

In our model each electricity industry represents a type of electricity plant. In the electricity supply system, plants are assigned duties according to their technical characteristics. The four electricity industries are grouped into two categories, high-flexible and low-flexible, according to their technical characteristics. We have defined a two-level nested electricity supply function that combines electricity produced by the four electricity industries. The supply structure allows substitution of electricity produced by industries within a category and between the two categories. This structure takes into account the differences in costs of electricity production by different plants and the differences in their technical characteristics.

Six types of production structure have been defined to represent substitution possibilities between factors, factor and energy products and among energy products in industries. Each production structure represents these substitution possibilities for a group of industries that have a similar pattern of energy consumption. These production structures are defined for five groups of industries: agricultural, manufacturing, road transport, combined cycle and steam electricity industry. The sixth, default, production structure covers the remaining industries.

Computer Implementation

The model has been implemented using the software GEMPACK — a general software for CGE modelling. Implementation of GE-PAK using GEMPACK

made modification of the model, through insertion or deletion of equations, very easy. Most importantly, the closure of the model can be changed in alternative simulations without making any change in the computer code; through swapping of endogenous variables with exogenous variables.

An Index of Social Welfare

In our model there are 14 types of households and any policy change affects real consumption of each household type differently. We have used Atkinson's social welfare function of "Mean of order τ " to compute an index of social welfare defined as the weighted average of changes in real per capita consumption of 14 types of household. The weights are function of real *per capita* consumption in the base year and the value of inequality-aversion parameter (τ). Thus, this index computes change in the social welfare for various levels of inequality aversion. For example a negative value of τ represents high degree of inequality aversion and it gives a lower weight to a change in real *per capita* consumption for high income groups. In the application of in this thesis we have used this index to compute the elasticities of social welfare cost with respect to indirect tax revenue when we increase in tax on different commodities.

Incorporation of International Trade theory

In our model, there are two sources of commodities supplies, domestic and imported, for each user category. The model specifies domestic supplies as imperfect substitute of imports. As the costs of domestic supply of a commodity change relative to its import price, there is a change in the source-composition of the commodity supply. This feature of the model is important from a developing country's point of view as international trade liberalisation is on their agenda of economic reform.

7.4 Development of Pakistan Data Base (PDB)

To prepare the PDB, we used various sources of data to expand and supplement the social accounting matrix. The major expansions in the social accounting matrix are:

- (i) disaggregation of a single mining industry into three industries: oil & gas, coal and other minerals industries. The oil & gas industry is a multiple output industry;
- (ii) disaggregation of the output of the refinery industry into six petroleum products. Accordingly, consumption and imports are also disaggregated;
- (iii) disaggregation of a single electricity industry into four industries; each represents a type of electricity plant.

7.5 Other Possible Applications of the Model

In this study we applied the model to analyse the effects of changes in domestic tax-mix and consumer subsidies on energy products. Similar exercises can be done for all other commodities. The model can be used to analyse the impact of a single exogenous shock or cumulative effects of more than one shock. For example during the 1970's oil crisis, the exogenous rise in world oil prices was accompanied by an increase in the demand for Pakistani workers in the oil exporting countries. Hence, there was a reduction in domestic labour supply and an increase in remittances along with a rise in the import price of oil. The model can be used to simulate the individual and cumulative effects of these shocks.

Like other developing countries, trade liberalisation and deregulation of the economy are on the agenda of economic planning in Pakistan. The macro and micro economic effects of these changes in economic policies can be evaluated by the model in detail, due to the high disaggregation of commodities and industries. For example, reductions in tariffs, the introduction of export subsidies or taxes can be simulated for large sets of commodities. Further, the disaggregation of households by region and income group helps in evaluating short-run adjustment costs in terms of real household consumption and the income-distributional effects of these reforms.

These issues are important for Pakistan and many other developing countries that are under pressures from the international aid giving agencies to liberalise their economies. It is important to evaluate the various economic and

social-equity effects of changes in economic policies in the short-term as the adjustment costs of change are typically thought to be high by the public, politicians and policy makers.

7.6 Limitations of the Model

Various CGE models have been built and applied in developing countries to address a variety of issues¹. However, each model has its own limitations. Here we outline some limitations of the theoretical structure and the empirical application of GE-PAK. Limitations of our analysis and improvements that can be made to the model are highlighted in two major areas; the theoretical specification and the data base.

Limitation of the Theory

In GE-PAK, we are limited in the specification of labour supply function. We assume that the supplies of labour by profession are either horizontal or vertical. In the first case, real wages are fixed by profession and shifts in the hours of labour supply are determined endogenously for the four labour categories. Alternatively, the supplies of labour hours by profession are assumed to be given exogenously and real wages are determined endogenously. In this case, an exogenous shift in the supply of labour by profession increases the supply in all income groups uniformly. This limitation is primarily due to the lack of empirically estimated labour-supply functions for Pakistan. We have tried to get around this problem by allowing inter-region household migration that makes the regional labour supply curves upward sloping. Nevertheless, these labour supply functions do not incorporate the response of a household to change its hours of labour in response to increase in real wages.

¹ Bandara (1989) has made a comprehensive survey of CGE models applications for the developing countries. He has given a summary of major features of 61 such CGE models and major results of their studies.

In common with many other CGE models, money is absent from our model; the model is limited to the real side of the economy where decisions are based on relative prices. It is implicitly assumed that the government adjusts the money supply of the economy in a way consistent with the changes in the domestic price level emerging from the results of our simulation. The introduction of equations for the financial sector linking money supply, the domestic price level, GDP, the balance of trade, exchange rate and aggregated investment would be a major extension of the model.

At present the model is suitable only for comparative-static analysis and is not capable of forecasting. In the static model, investment decisions do not change as the rates of returns change across industries in a policy simulation. Thus, the effects of reallocation of resources in capital formation for future production are not taken into account. The introduction of dynamics into the model would be an important improvement.

Limitation of Data

The model is based on two sets of data; a social accounting matrix that includes an Input-Output matrix and various income-expenditure matrices of major institutions of the economy, and a set of elasticity parameters and coefficients. To prepare the PDB, we used various sources of data to expand and supplement the social accounting matrix. However, some data values were based on 'best guesses'. An example is the disaggregation of returns to fixed factors into land and capital in the agricultural, mining and hydro electricity industries. We have discussed all these problems and our assumptions in detail in Chapter 5. Improved estimates of their values would considerably enhance the usefulness of the model. Ideally, this would involve the estimation of those elasticity parameters econometrically. That would require more time and research resources than were available for this study. Nevertheless, these estimated values of parameter will only improve the precision and the reliability of the model's results.

7.7 Conclusion

In this study we have developed a CGE model for the Pakistan economy that incorporates some of its key structural characteristics and embodies details of energy production and consumption. This model was used to demonstrate its potential for policy analysis by analysing energy pricing policy in Pakistan.

The simulation results of some hypothetical changes in various types of taxes on energy products show the capability of the model to provide detailed information which are extremely useful in analysis of a policy issue.

Appendix A[†] Percentage-Change Equations of a CES Nest

Problem: Choose inputs X_i ($i = 1$ to N), to minimise the cost $\sum_i P_i X_i$ of producing given output Z , subject to the CES production function:

$$Z = \left(\sum_i \delta_i X_i^{-\rho} \right)^{-1/\rho}. \quad (\text{A1})$$

The associated first order conditions are:

$$P_k = \lambda \frac{\partial Z}{\partial X_k} = \lambda \delta_k X_k^{-(1+\rho)} \left(\sum_i \delta_i X_i^{-\rho} \right)^{-(1+\rho)/\rho}. \quad (\text{A2})$$

Hence

$$\frac{P_k}{P_i} = \frac{\delta_k}{\delta_i} \left(\frac{X_i}{X_k} \right)^{1+\rho}, \quad (\text{A3})$$

or

$$X_i^{-\rho} = \left(\frac{\delta_i P_k}{\delta_k P_i} \right)^{-\rho/(1+\rho)} X_k^{-\rho}. \quad (\text{A4})$$

Substituting the above expression back into the production function we obtain:

$$Z = X_k \left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k} \right]^{\rho/(1+\rho)} \right)^{-1/\rho}. \quad (\text{A5})$$

This gives the input demand functions:

$$X_k = Z \left(\sum_i \delta_i \left[\frac{\delta_k P_i}{\delta_i P_k} \right]^{\rho/(1+\rho)} \right)^{1/\rho}, \quad (\text{A6})$$

$$\text{or } X_k = Z \delta_k^{1/(1+\rho)} \left[\frac{P_k}{P_{ave}} \right]^{-1/(1+\rho)}, \quad (\text{A7})$$

where

$$P_{ave} = \left(\sum_i \delta_i^{1/(1+\rho)} P_i^{\rho/(1+\rho)} \right)^{-(1+\rho)/\rho}. \quad (\text{A8})$$

Transforming to percentage changes (see Appendix B) we get:

$$x_k = z - \sigma(p_k - p_{ave}), \quad (\text{A9})$$

$$\text{and } p_{ave} = \sum_i S_i p_i, \quad (\text{A10})$$

where

$$\sigma = \frac{1}{\rho+1} \text{ and } S_i = \delta_i^{1/(1+\rho)} P_i^{\rho/(1+\rho)} / \sum_k \delta_k^{1/(1+\rho)} P_k^{\rho/(1+\rho)}. \quad (\text{A11})$$

Multiplying both sides of (A7) by P_k we get:

$$P_k X_k = Z \delta_k^{1/(1+\rho)} P_k^{\rho/(1+\rho)} P_{ave}^{1/(1+\rho)}. \quad (\text{A12})$$

Hence

$$\frac{P_k X_k}{\sum_i P_i X_i} = \delta_k^{1/(1+\rho)} P_k^{\rho/(1+\rho)} / \sum_i \delta_i^{1/(1+\rho)} P_i^{\rho/(1+\rho)} = S_i, \quad (\text{A13})$$

i.e., the S_i of (A11) turn out to be cost shares.

With technical change terms, we must choose inputs X_i so as to:

$$\text{minimise } \sum_i P_i X_i \text{ subject to: } Z = \left(\sum_i \delta_i \left[\frac{X_i}{A_i} \right]^p \right)^{-1/p}. \quad (\text{A14})$$

$$\text{Setting } \tilde{X}_i = \frac{X_i}{A_i} \text{ and } \tilde{P}_i = P_i A_i \text{ we get:} \quad (\text{A15})$$

$$\text{minimise } \sum_i \tilde{P}_i \tilde{X}_i \text{ subject to: } Z = \left(\sum_i \delta_i \tilde{X}_i^p \right)^{-1/p}, \quad (\text{A16})$$

which has the same form as problem (A1). Hence the percentage-change form of the demand equations is:

$$\tilde{x}_k = z - \sigma(\tilde{p}_k - \tilde{p}_{ave}), \quad (\text{A17})$$

$$\text{and } \tilde{p}_{ave} = \sum_i S_i \tilde{p}_i. \quad (\text{A18})$$

But from (A15), $\tilde{x}_k = x_k - a_k$, and $\tilde{p}_i = p_i + a_i$, giving:

$$x_k - a_k = z - \sigma(p_k + a_k - \tilde{p}_{ave}). \quad (\text{A19})$$

$$\text{and } \tilde{p}_{ave} = \sum_i S_i (p_i + a_i). \quad (\text{A20})$$

When technical change terms are included, we call z and $\tilde{p}_{ave}$ *effective* indices of input quantities and prices.

† This appendix has been taken from Horridge *et al.* (1993)

Appendix B† Deriving Percentage-Change Forms

Using first principles, a levels equation, for example,

$$Y = X^2 + Z,$$

is turned into percentage-change form by first taking total differentials:

$$dY = 2XdX + dZ.$$

Percentage changes x , y , and z are defined *via*:

$$y = 100 \frac{dY}{Y} \text{ or } dY = \frac{Yy}{100}, \text{ similarly } dX = \frac{Xx}{100} \text{ and } dZ = \frac{Zz}{100}.$$

Thus our sample equation becomes:

$$\frac{Yy}{100} = 2X \frac{Xx}{100} + \frac{Zz}{100}, \text{ or } Yy = 2X^2x + Zz.$$

In practice such formal derivations are often unnecessary. Most percentage-change equations follow standard patterns which the modeller soon recognizes. Some of these are shown in Table B1.

Table B1 Examples of Percentage-Change Forms

Example	Original or Levels Form	Percentage-Change Form
1	$Y = 4$	$y = 0$
2	$Y = X$	$y = x$
3	$Y = 3X$	$y = x$
4	$Y = XZ$	$y = x + z$
5	$Y = X/Z$	$y = x - z$ or $100(Z)\Delta Y = Xx - Xz$
6	$X_1 = M/4P_1$	$x_1 = m - p_1$
7	$Y = X^3$	$y = 3x$
8	$Y = X^\alpha$	$y = \alpha x$ (α assumed constant)
9	$Y = X + Z$	$Yy = Xx + Zz$ or $y = S_x x + S_z z$ where $S_x = X/Y$, etc
10	$Y = X - Z$	$Yy = Xx - Zz$ or $y = S_x x - S_z z$ where $S_x = X/Y$, etc, or $100(\Delta Y) = Xx - Zz$
11	$PY = PX + PZ$	$PYy = PXx + PZz$ or $y = S_x x + S_z z$ where $S_x = PX/PY$, etc
12	$Z = \sum X_i$	$Zz = \sum X_i x_i$
13	$XP = \sum X_i P_i$	$XP(x+p) = \sum X_i P_i (x_i + p_i)$

The third alternative form for example 10 shows how ordinary and percentage changes may be mixed. It is based on the identity $Yy \dots 100\Delta Y$. See also example 5.

Variables can only be added or subtracted (as in examples 9 and 12) where they share the same units. In adding quantities, we can normally identify a common price (often the basic price). By multiplying through additive expressions by a common price, we can express the coefficients of percentage-change equations as functions of flows, rather than quantities, thus obviating the need to define physical units (compare examples 9 and 11).

[†] This appendix has been taken from Horridge *et al.* (1993)

Appendix C Equations of GE-PAK

Block 1 Equations for region-profession specific labour demand

$$\begin{aligned}
 xlab_{rpj} &= xlab_{rpj} + allab_{pj} + allab_{rpj} \\
 &\quad - \sigma_{PRF_{rj}} [\{p1lab_{rpj} + allab_{rpj}\} - p1lab_{pj}], \\
 &\quad r \in REG, p \in PRF, j \in IND, (1.1)
 \end{aligned}$$

$$\begin{aligned}
 p1lab_{pj} &= \frac{1}{VLAB_{pj}} \sum_{p \in PRF} \{VLAB_{rpj} \times (p1lab_{rpj} + allab_{rpj})\}, \\
 &\quad r \in REG, j \in IND, (1.2)
 \end{aligned}$$

$$\begin{aligned}
 p1lab_{rpj} &= \frac{1}{VLAB_{rpj}} \sum_{r \in REG} VLAB_{rpj} \times \{p1lab_{pj} + allab_{pj}\}, \\
 &\quad j \in IND. (1.3)
 \end{aligned}$$

Block 2 Demand equations for capital and land by type

$$x1cap_{cj} = x1cap_{cj}, \quad c \in CAP, j \in IND, (2.1)$$

$$p1cap_{cj} = p1cap_{cj}, \quad c \in CAP, j \in IND, (2.2)$$

$$x1lnd_{dj} = x1lnd_{dj}, \quad d \in LND, j \in IND, (2.3)$$

$$p1lnd_{dj} = p1lnd_{dj}, \quad d \in LND, j \in IND. (2.4)$$

Block 3 Equations of intermediate demand by source

$$\begin{aligned}
 x1_{isj} &= x1_{sij} + a1_{isj} - \sigma_{COM1_i} [\{p1_{isj} + a1_{isj}\} - p1_{sij}], \\
 &\quad i \in COM, s \in SRC, j \in IND, (3.1)
 \end{aligned}$$

$$\begin{aligned}
 p1_{sij} &= \frac{1}{VIBAS_{sij}} \sum_{s \in SRC} VIBAS_{isj} (p1_{isj} + a1_{isj}), \\
 &\quad i \in COM, j \in IND. (3.2)
 \end{aligned}$$

Block 4 Demand equations for land, labour and capital

$$x1cap\_cj = x1prm_j + alcap\_cj - \sigma FAC_j [\{plcap\_cj + alcap\_cj\} - plprm_j], \quad j \in IND, (4.1)$$

$$x1lab\_rpj = x1prm_j + allab\_rpj - \sigma FAC_j [\{plab\_rpj + allab\_rpj\} - plprm_j], \quad j \in IND, (4.2)$$

$$x1lnd\_dj = x1prm_j + allnd\_dj - \sigma FAC_j [\{pllnd\_dj + allnd\_dj\} - plprm_j], \quad j \in IND, (4.3)$$

$$plprm_j = \frac{1}{V1PRM_j} \left(V1CAP\_cj \times \{plcap\_cj + alcap\_cj + alprm_j\} \right. \\ \left. + V1LND\_dj \times \{pllnd\_dj + allnd\_dj + alprm_j\} \right. \\ \left. + V1LAB\_rpj \times \{pllab\_rpj + allab\_rpj + alprm_j\} \right), \quad j \in IND. (4.4)$$

Block 5 Composite-inputs demand equations

$$x1oct_j = atot_j + aloct_j + z_j, \quad j \in IND, (5.1)$$

$$x1prm_j = atot_j + alprm_j + z_j, \quad j \in IND, (5.2)$$

$$x1\_sij = atot_j + al\_sj + z_j, \quad i \in COM, j \in IND, (5.3)$$

$$p0ind_j - a_j = \frac{1}{COSTS_j} \left(\sum_{i \in COM} \sum_{s \in SRC} PUR1_{isj} \times pl_{isj} \right. \\ \left. + \sum_{r \in REG} \sum_{p \in PRF} V1LAB_{rpj} \times pllab_{rpj} \right. \\ \left. + V1CAP\_cj \times plcap\_cj \right. \\ \left. + V1LND\_dj \times pllnd\_dj + V1OCT_j \times ploct_j \right), \quad j \in IND, (5.4)$$

$$a_j - atot_j = \sum_{i \in COM} (PUR1_{sj} \times al\_sj + \sum_{s \in SRC} PUR1_{isj} \times al_{isj}) \\ + V1PRM_j \times alprm_j + \sum_{r \in REG} \sum_{p \in PRF} V1LAB_{rpj} \times allab_{rpj} \\ + LAB\_rpj \times allab\_rpj + V1CAP\_cj \times alcap\_cj + V1LND\_dj \times allnd\_dj \\ + V1OCT_j \times aloct_j, \quad j \in IND, (5.5)$$

$$ploct_j = xi3 + floct_j, \quad j \in IND. (5.6)$$

Block 6 Equations for output-mix in industries

$$x0_{ij} = z_j + \sigma_{OUT_j} (p0_{dom_i} - p0_{ind_j}), \quad i \in COM, j \in IND, \quad (6.1)$$

$$p0_{ind_j} = \frac{1}{\sum_{i \in COM} MAKE_{ij}} \sum_{i \in COM} MAKE_{ij} \times p0_{dom_i}, \quad j \in NONIELE, \quad (6.2)$$

$$x0_{dom_i} = \frac{1}{\sum_{j \in NONIELE} MAKE_{ij}} \sum_{j \in NONIELE} MAKE_{ij} \times x0_{ij}, \quad i \in NONCELE, \quad (6.3)$$

Block 7 Equations of electricity supply structure

$$x0_{ij} = x0_{elec\_lflex} - \sigma_{IELEL} (p0_{ind_j} - p0_{elec\_lflex}), \quad i = \text{electricity}, j \in ILFLX, \quad (7.1)$$

$$p0_{elec\_lflex} = \frac{1}{\sum_{j \in ILFLX} MAKE_{ij}} \left(\sum_{j \in ILFLX} MAKE_{ij} \times p0_{ind_j} \right), \quad i = \text{electricity}, \quad (7.2)$$

$$x0_{ij} = x0_{elec\_hflex} - \sigma_{IELEM} (p0_{ind_j} - p0_{elec\_hflex}), \quad i = \text{electricity}, j = IMFLX, \quad (7.3)$$

$$p0_{elec\_hflex} = \frac{1}{\sum_{j \in IHFLX} MAKE_{ij}} \left(\sum_{j \in IHFLX} MAKE_{ij} \times p0_{ind_j} \right), \quad i = \text{electricity}, \quad (7.4)$$

$$x0_{elec\_lfflex} = x0_{dom_i} - \sigma_{IELE} (p0_{elec\_lflex} - p0_{dom_i}), \quad i = \text{electricity}, \quad (7.5)$$

$$x0_{elec\_hflex} = x0_{dom_i} - \sigma_{IELE} (p0_{elec\_hflex} - p0_{dom_i}), \quad i = \text{electricity}, \quad (7.6)$$

$$p0_{dom_i} = \frac{1}{\sum_{j \in IELE} MAKE_{ij}} \left(\sum_{j \in IELE} MAKE_{ij} \times p0_{ind_j} \right), \quad i = \text{electricity}. \quad (7.7)$$

Block 8 Equations of demand for commodities for capital formation

$$x2_{isj} = x2_{sij} + a2_{isj} - \sigma_{COM2i} [\{ p2_{isj} + a2_{isj} \} - p2_{sij}],$$

$$i \in COM, s \in SRC, j \in IND, (8.1)$$

$$p2_{sij} = \frac{1}{PUR2_{sij}} \left(\sum_{s \in SRC} PUR2_{isj} \{ p2_{isj} + a2_{isj} \} \right),$$

$$i \in COM, j \in IND, (8.2)$$

$$x2_{sij} = y_j + a2_{isj} + a2_{sij},$$

$$i \in COM, j \in IND, (8.3)$$

$$p2_{isj} = a2_{isj} + \frac{1}{PUR2_{isj}} \left(\sum_{i \in COM} PUR2_{sij} \{ p2_{sij} + a2_{sij} \} \right),$$

$$j \in IND. (8.4)$$

Block 9 Coefficients in household demand equations

$$ALPHA_{I_{km}} = ALPHA_m \times EPS_{km},$$

$$k \in ITM, r \in REG, n \in INC, (9.1)$$

$$ALPHA_m = (-1/FRISCH_m),$$

$$r \in REG, n \in INC, (9.2)$$

$$DELTA_{km} = EPS_{km} \times \frac{VITEM_{km}}{VITEM_{k_m}},$$

$$k \in ITM, r \in REG, n \in INC. (9.3)$$

Block 10 Equations for household demand

$$\begin{aligned} xitem_{km} = & [1 - ALPHA\_I_{km}] [q\_p_m + aitemsub_{km}] \\ & + ALPHA\_I_{km} \times [luxexp_m + aitemlux_{km} - pitem_k], \\ & k \in ITM, r \in REG, n \in INC, (10.1) \end{aligned}$$

$$\begin{aligned} aitemlux_{km} = & aitemsub_{km} - \sum_{l \in ITM} (DELTA_{lm} \times aitemsub_{lm}), \\ & k \in ITM, r \in REG, n \in INC, (10.2) \end{aligned}$$

$$\begin{aligned} aitemsub_{km} = & aitem_{km} - \sum_{l \in ITM} (VITEM_{lm} \times aitem_{lm}), \\ & k \in ITM, r \in REG, n \in INC, (10.3) \end{aligned}$$

$$\begin{aligned} utility_m = & luxexp_m - q\_p_m - \sum_{k \in ITM} (DELTA_{km} \times pitem_k), \\ & r \in REG, n \in INC, (10.4) \end{aligned}$$

$$\begin{aligned} chou_m = & \frac{1}{VITEM\_k_m} \sum_{k \in ITM} (VITEM_{km} \times \{xitem_{km} + pitem_k\}), \\ & r \in REG, n \in INC. (10.5) \end{aligned}$$

Block 11 Demand equations for formation of items

$$\begin{aligned} xitem\_m_k = & \frac{1}{VITEM\_k_m} \left(\sum_{r \in REG} \sum_{n \in INC} VITEM_{km} \times xitem_{km} \right), \\ & k \in ITM, (11.1) \end{aligned}$$

$$x3item\_s_{ki} = xitem\_m_k, \quad k \in ITM, i \in COM, (11.2)$$

$$\begin{aligned} pitem_k = & \frac{1}{COMITEM\_is_k} \left(\sum_{i \in COM} COMITEM_{s_{ki}} \times p3item\_s_{ki} \right), \\ & k \in ITM, (11.3) \end{aligned}$$

$$\begin{aligned} x3item_{kis} = & x3item\_s_{ki} - \sigma COM3_i [p3_{is} - p3item\_s_{ki}], \\ & k \in ITM, i \in COM, s \in SRC, (11.4) \end{aligned}$$

$$\begin{aligned} p3item\_s_{ki} = & \frac{1}{COMITEM\_s_{ki}} \left(\sum_{s \in SRC} COMITEM_{kis} \times p3_{is} \right), \\ & k \in ITM, i \in COM, (11.5) \end{aligned}$$

$$\begin{aligned} x3_{is} = & \frac{1}{COMITEM\_k_{is}} \left(\sum_{k \in ITM} COMITEM_{kis} \times x3item_{kis} \right), \\ & i \in COM, s \in SRC. (11.6) \end{aligned}$$

Block 12 Equations for exports demand and government consumption

$$x4_i - feq_i = EXP\_ELAST_i [pe_i - fep_i], \quad i \in COM, \quad (12.1)$$

$$pe_i + phi = \frac{1}{PUR4_i} \left((V4BAS_i + V4TAX_i) \times (p0dom_i + t4_i) + \sum_{m \in MAR} V4MAR_{im} [p0dom_i + a4mar_{im}] \right), \quad i \in COM, \quad (12.2)$$

$$x5_{is} = chour\_m + f5_{is} + f5tot, \quad i \in COM, s \in SRC. \quad (12.3)$$

Block 13 Equations of demands for margin-goods

$$x1mar_{isjm} = x1_{isj} + a1mar_{isjm}, \quad i \in COM, s \in SRC, j \in IND, m \in MAR, \quad (13.1)$$

$$x2mar_{isjm} = x2_{isj} + a2mar_{isjm}, \quad i \in COM, s \in SRC, j \in IND, m \in MAR, \quad (13.2)$$

$$x3mar_{ism} = x3_{is} + a3mar_{ism}, \quad i \in COM, s \in SRC, m \in MAR, \quad (13.3)$$

$$x4mar_{im} = x4_i + a4mar_{im}, \quad i \in COM, m \in MAR, \quad (13.4)$$

$$x5mar_{ism} = x5_{is} + a5mar_{ism}, \quad i \in COM, s \in SRC, m \in MAR. \quad (13.5)$$

Block 14 Equations for purchasers' prices

$$p0_{is} = p0dom_i, \quad s = \text{domestic}, i \in COM, \quad (14.1)$$

$$p0_{is} = p0imp_i, \quad s = \text{imported}, i \in COM, \quad (14.2)$$

$$p1_{isj} = \frac{1}{PUR1_{isj}} \left([V1BAS_{isj} + V1TAX_{isj}] \times \{p0_{is} + t1_{isj}\} + \sum_{m \in MAR} (V1MAR_{isjm} \{p0dom_m + a1mar_{isjm}\}) \right), \quad i \in COM, s \in SRC, j \in IND, \quad (14.3)$$

$$p2_{isj} = \frac{1}{PUR2_{isj}} \left([V2BAS_{isj} + V2TAX_{isj}] \times \{p0_{is} + t2_{isj}\} + \sum_{m \in MAR} (V2MAR_{isjm} \{p0dom_m + a2mar_{isjm}\}) \right), \quad i \in COM, s \in SRC, j \in IND, \quad (14.4)$$

$$p3_{is} = \frac{1}{PUR3_{is}} \left([V3BAS_{is} + V3TAX_{is}] \times \{p0_{is} + t3_{is}\} + \sum_{m \in MAR} V3MAR_{ism} \{p0dom_m + a3mar_{ism}\} \right), \quad i \in COM, s \in SRC, \quad (14.5)$$

$$p5_{is} = \frac{1}{PUR5_{is}} \left([V5BAS_{is} + V5TAX_{is}] \times \{ p0_{is} + t5_{is} \} \right. \\ \left. + \sum_{m \in MAR} V5MAR_{ism} \{ p0_{dom_m} + a5_{mar_{ism}} \} \right), \\ i \in COM, s \in SRC, (14.6)$$

$$p0_{imp_i} = pm_i + phi + tm_i, \quad i \in COM. (14.7)$$

Block 15 Equations for indirect taxes

$$t1_{isj} = t_{is} + t1_{isj} + t0 + t1_{eij}, \quad i \in COM, s \in SRC, j \in IND, (15.1)$$

$$t2_{isj} = t_{is} + t2_{isj} + t0 + t2_{eij}, \quad i \in COM, s \in SRC, j \in IND, (15.2)$$

$$t3_{is} = t_{is} + t3_{is} + t0 + t3_{ei}, \quad i \in COM, s \in SRC, (15.3)$$

$$t5_{is} = t_{is} + t5_{is} + t0, \quad i \in COM, s \in SRC. (15.4)$$

Block 16 Tax rate equations for commodities with regulated prices

$$fp0_{pub_{as}} = t_{as} + p0_{as}, \quad a \in ADM, s \in SRC, (16.1)$$

Block 17 Market clearing equations for commodities

$$x0_{dom_m} = \frac{1}{SALES_j} \left[\sum_{j \in IND} V1BAS_{mlj} \times x1_{mlj} + \sum_{j \in IND} V2BAS_{mlj} \times x2_{mlj} \right. \\ + V3BAS_{ml} \times x3_{ml} + V4BAS_m \times x4_m \\ + V5BAS_{ml} \times x5_{ml} \\ + \sum_{i \in COM} \left\{ V4MAR_{im} \times x4_{mar_{im}} \right. \\ + \sum_{s \in SRC} V3MAR_{ism} \times x3_{mar_{ism}} \\ + \sum_{s \in SRC} V5MAR_{ism} \times x5_{mar_{ism}} \\ + \sum_{s \in SRC} \sum_{j \in IND} V1MAR_{ismj} \times x1_{mar_{ismj}} \\ \left. + \sum_{s \in SRC} \sum_{j \in IND} V2MAR_{ismj} \times x2_{mar_{ismj}} \right\} \left. \right], \\ l=domestic, m \in MAR, (17.1)$$

$$x0dom_i = \frac{1}{SALES_j} \left[\sum_{j \in IND} V1BAS_{ij} \times x1_{ij} + \sum_{j \in IND} V2BAS_{ij} \times x2_{ij} + V3BAS_{il} \times x3_{il} + V4BAS_i \times x4_i + V5BAS_{il} \times x5_{il} \right],$$

$l=domestic, i \in NONMAR, (17.2)$

$$x0imp_i = \frac{1}{VOIMP_j} \left[\sum_{j \in IND} V1BAS_{ij} \times x1_{ij} + \sum_{j \in IND} V2BAS_{ij} \times x2_{ij} + V3BAS_{il} \times x3_{il} + V5BAS_{il} \times x5_{il} \right],$$

$l=imported, i \in COM. (17.3)$

Block 18 Aggregate factor demand equations

$$lambda_{rp} = \frac{1}{V1LAB\_jrp} \sum_{j \in IND} V1LAB_{rpj} \times x1lab_{rpj}, \quad r \in REG, p \in PRF, (18.1)$$

$$x1cap\_jc = \frac{1}{V1CAP\_jc} \sum_{j \in IND} V1CAP_{cj} \times x1cap_{cj}, \quad c \in CAP, (18.2)$$

$$x1lnd\_jd = \frac{1}{V1LND\_jd} \sum_{j \in IND} V1LND_{dj} \times x1lnd_{dj}, \quad d \in LND, (18.3)$$

$$lambda\_pr = \frac{1}{V1LAB\_pj_r} \sum_{p \in PRF} V1LAB\_jrp \times lambda_{rp}, \quad r \in REG, (18.4)$$

$$lambda\_rp = \frac{1}{V1LAB\_rp} \sum_{r \in REG} V1LAB\_jrp \times lambda_{rp}, \quad p \in PRF. (18.5)$$

Block 19 Equations of aggregate demand for final consumption, exports, imports and indirect-tax revenues

$$exp = \frac{1}{PUR4\_i} \sum_{i \in COM} PUR4_i \times [pe_i + x4_i], \quad (19.1)$$

$$imp = \frac{1}{VOIMP\_i} \sum_{i \in COM} VOIMP_i \times [pm_i + x0imp_i], \quad (19.2)$$

$$expvol = exp + phi - xi4, \quad (19.3)$$

$$impvol = imp + phi - xim, \quad (19.4)$$

$$chour_{rm} = chou_{rm} - xiitem_{rm}, \quad r \in REG, n \in INC, (19.5)$$

$$perconr_{rm} = chour_{rm} - q\_p_{rm} - hsize_{rm}, \quad r \in REG, n \in INC, (19.6)$$

$$chour\_rm = \frac{1}{VITEM\_km} \sum_{r \in REG} \sum_{n \in INC} VITEM_{km} \times chour_{rm}, \quad (19.7)$$

$$chou\_rm = \frac{1}{VITEM\_km} \sum_{r \in REG} \sum_{n \in INC} VITEM_{km} \times chou_{rm}, \quad (19.8)$$

$$\text{inv} = \text{invr} + \text{xi2}, \quad (19.9)$$

$$\text{invr} = \frac{1}{\text{PUR2\_isj}} \sum_{j \in \text{IND}} \text{PUR2\_isj} \times y_j, \quad (19.10)$$

$$\text{oth} = \text{othr} + \text{xi5}, \quad (19.11)$$

$$\text{oth} = \frac{1}{\text{PUR5\_is}} \sum_{i \in \text{COM}} \sum_{s \in \text{SRC}} \text{PUR5\_is} \times x5_{is}, \quad (19.12)$$

$$\text{labrev} = \frac{1}{\text{VILAB\_rpj}} \sum_{j \in \text{IND}} \sum_{r \in \text{REG}} \sum_{p \in \text{PRF}} \text{VILAB\_rpj} \times (\text{p1lab\_rpj} + \text{x1lab\_rpj}), \quad (19.13)$$

$$\text{caprev} = \frac{1}{\text{VICAP\_cj}} \sum_{j \in \text{IND}} \sum_{c \in \text{CAP}} \text{VICAP\_cj} \times (\text{p1cap\_cj} + \text{x1cap\_cj}), \quad (19.14)$$

$$\text{lndrev} = \frac{1}{\text{VILND\_dj}} \sum_{j \in \text{IND}} \sum_{d \in \text{LND}} \text{VILND\_dj} \times (\text{p1lnd\_dj} + \text{x1lnd\_dj}), \quad (19.15)$$

$$\text{octrev} = \frac{1}{\text{VIOCT\_j}} \sum_{j \in \text{IND}} \text{VIOCT\_j} \times (\text{p1loct\_j} + \text{x1loct\_j}), \quad (19.16)$$

$$\begin{aligned} \text{t1rev\_isj} = \frac{1}{\text{V1TAX\_isj}} \sum_{i \in \text{COM}} \sum_{s \in \text{SRC}} \sum_{j \in \text{IND}} & (\text{V1TAX\_isj} \times \{ \text{p0}_{is} + \text{x1}_{isj} \} \\ & + [\text{V1TAX\_isj} + \text{V1BAS\_isj}] \times \text{t1}_{isj}), \end{aligned} \quad (19.17)$$

$$\begin{aligned} \text{t2rev\_isj} = \frac{1}{\text{V2TAX\_isj}} \sum_{i \in \text{COM}} \sum_{s \in \text{SRC}} \sum_{j \in \text{IND}} & (\text{V2TAX\_isj} \times \{ \text{p0}_{is} + \text{x2}_{isj} \} \\ & + [\text{V2TAX\_isj} + \text{V2BAS\_isj}] \times \text{t2}_{isj}), \end{aligned} \quad (19.18)$$

$$\begin{aligned} \text{t3rev\_is} = \frac{1}{\text{V3TAX\_is}} \sum_{i \in \text{COM}} \sum_{s \in \text{SRC}} & (\text{V3TAX\_is} \times \{ \text{p0}_{is} + \text{x3}_{is} \} \\ & + [\text{V3TAX\_is} + \text{V3BAS\_is}] \times \text{t3}_{is}), \end{aligned} \quad (19.19)$$

$$\begin{aligned} \text{t4rev\_i} = \frac{1}{\text{V4TAX\_i}} \sum_{i \in \text{COM}} & (\text{V4TAX\_i} \times \{ \text{p0}_{\text{dom}_i} + \text{x4}_i \} \\ & + [\text{V4TAX\_i} + \text{V1BAS}_i] \times \text{t4}_i), \end{aligned} \quad (19.20)$$

$$\begin{aligned} \text{t5rev\_is} = \frac{1}{\text{V5TAX\_is}} \sum_{i \in \text{COM}} \sum_{s \in \text{SRC}} & (\text{V5TAX\_is} \times \{ \text{p0}_{is} + \text{x5}_{is} \} \\ & + [\text{V5TAX\_is} + \text{V5BAS\_is}] \times \text{t5}_{is}), \end{aligned} \quad (19.21)$$

$$\begin{aligned} \text{tmrev\_i} = \frac{1}{\text{V0TAR\_i}} \sum_{i \in \text{COM}} & \text{V0TAR}_i \{ \text{pm}_i + \text{phi} + \text{x0imp}_i \} \\ & + \sum_{i \in \text{COM}} \text{IMPORTS}_i \times \text{tm}_i, \end{aligned} \quad (19.22)$$

$$t0rev = \frac{1}{V0TAX} (V1TAX_{isj} \times t1rev_{isj} + V2TAX_{isj} \times t2rev_{isj} \\ + V3TAX_{is} \times t3rev_{is} + V4TAX_i \times t4rev_i \\ + V5TAX_i \times t5rev_{is} + V0TAR \times tmrev_i \\ + V1OCT_j \times octrev). \quad (19.23)$$

Block 20 Equations for GDP and the balance of trade

$$delB = (PUR4_i \times exp - V0IMP_i \times imp) \times 100.0 / 1000.0, \quad (20.1)$$

$$gdpexp = \frac{1}{GDPEXP} (VITEM_{km} \times chou_m + PUR2_{isj} \times inv \\ + PUR5_{is} \times oth \\ + PUR4_i \times (exp + phi) - V0IMP_i \times (imp + phi)), \quad (20.2)$$

$$gdpinc = \frac{1}{GDPINC} (V1LND_{dj} \times lndrev + V1CAP_{cj} \times caprev \\ + V1LAB_{rpj} \times labrev \\ + V0TAX \times t0rev), \quad (20.3)$$

$$gdpreal = gdpexp - xigdp, \quad (20.4)$$

$$x1cap_{cj} = \frac{1}{V1CAP_{cj}} \sum_j V1CAP_{cj} \times x1cap_{cj}, \quad (20.5)$$

$$x1lab_{rpj} = \frac{1}{V1LAB_{rpj}} \sum_j V1LAB_{rpj} \times x1lab_{rpj}, \quad (20.6)$$

$$x1lnd_{dj} = \frac{1}{V1LND_{dj}} \sum_j V1LND_{dj} \times x1lnd_{dj}. \quad (20.7)$$

Block 21 Equations for investment allocation

$$r0_j = QCOEF_j \times [p1cap_{cj} - p2_{isj}], \quad j \in IND, \quad (21.1)$$

$$r0_j - r_{tot} = BETA_{Rj} \times [x1cap_{cj} - x1cap_{cj}] + fr0_j, \quad j \in IND, \quad (21.2)$$

$$x1cap_{cj} = INV\_ELAST_j \times y_j + fx1cap_{cj}, \quad j \in IND. \quad (21.3)$$

Block 22 Equations of price indices

$$xi2 = \frac{1}{PUR2_{isj}} \sum_{i \in COM} \sum_{s \in SRC} \sum_{j \in IND} PUR2_{isj} \times p2_{isj}, \quad (22.1)$$

$$xi3 = \frac{1}{PUR3_{is}} \sum_{i \in COM} \sum_{s \in SRC} PUR3_{is} \times p3_{is}, \quad (22.2)$$

$$xiitem_m = \frac{1}{VITEM_{km}} \sum_{k \in ITM} VITEM_{km} \times pitem_k, \\ r \in REG, n \in INC, \quad (22.3)$$

$$xi5 = \frac{1}{PUR5_{is}} \sum_{i \in COM} \sum_{s \in SRC} PUR5_{is} \times p5cs_{is}, \quad (22.4)$$

$$xi4 - phi = \frac{1}{PUR4\_i} \sum_{i \in COM} PUR4_i \times pe_i, \quad (22.5)$$

$$xim - phi = \frac{1}{V0IMP\_i} \sum_{i \in COM} V0IMP_i \times pm_i, \quad (22.6)$$

$$ximp0 = \frac{1}{IMPORTS\_i} \sum_{i \in COM} IMPORTS_i \times p0imp_i, \quad (22.7)$$

$$xigdp = \frac{1}{GDPEXP} (PUR2\_isj \times xi2 + PUR3\_is \times xi3 + PUR4\_i \times xi4 + PUR5\_is \times xi5 - V0IMP\_i \times xim), \quad (22.8)$$

$$xifac = \frac{1}{V1PRM\_j} \sum_{j \in IND} V1PRM_j \times p1prm_j. \quad (22.9)$$

Block 23 Equations for prices indices of primary factors by type for income mapping

$$p1lab\_jr = \frac{1}{V1LAB\_jr} \sum_{j \in IND} V1LAB_{rpj} \times p1lab_{rpj}, \quad r \in REG, p \in PRF, \quad (23.1)$$

$$p1cap\_jc = \frac{1}{V1CAP\_jc} \sum_{j \in IND} V1CAP_{cj} \times p1cap_{cj}, \quad c \in CAP, \quad (23.2)$$

$$p1lnd\_jd = \frac{1}{V1LND\_jd} \sum_{j \in IND} V1LND_{dj} \times p1lnd_{dj}, \quad d \in LND. \quad (23.3)$$

Block 24 Market clearing equations for primary factors

$$lambda_{rp} = \frac{1}{VYHOULAB\_n_{rp}} \sum_{n \in INC} VYHOULAB_{mp} \times ehoulab_{mp} \quad r \in REG, p \in PRF, \quad (24.1)$$

$$x1cap\_jc = \frac{1}{V1CAP\_jc} \left(\sum_{r \in REG} \sum_{n \in INC} VYHOUCAP_{mc} \times ehoucap_{mc} + \sum_{o \in COR} VYCORCAP_{oc} \times ecorcap_{oc} + YGOVCAP_c \times egovcap_c + VYROWCAP_c \times erowcap_c \right), \quad c \in CAP, \quad (24.2)$$

$$\begin{aligned}
x1lnd_{jd} = & \frac{1}{V1LND_{jd}} \left(\sum_{r \in REG} \sum_{n \in INC} VYHOULND_{rnd} \times ehoulnd_{rnd} \right. \\
& + \sum_{o \in COR} VYCORLND_{od} \times ecorlnd_{od} \\
& + VYGOVLND_d \times egovlnd_d \\
& \left. + VYROWLND_d \times erowlnd_d \right), \quad d \in LND. \quad (24.3)
\end{aligned}$$

Block 25 Rural-urban migration and real wages

$$q_{mp} = q_{rnp} + \sigma REG_p \times (p1labr_{jnp} - p1labr_{rjnp}), \quad r \in REG, n \in INC, p \in PRF, \quad (25.1)$$

$$p1labr_{rjnp} = \frac{1}{VYHOULAB_{rnp}} \sum_{r \in REG} VYHOULAB_{mp} \times p1labr_{jnp}, \quad n \in INC, p \in PRF, \quad (25.2)$$

$$q_{pm} = \frac{1}{ADJ_p \times VYHOULAB_{pm}} \sum_{p \in PRF} (VYHOULAB_{mp} \times ADJ_p) \times q_{mp}, \quad r \in REG, n \in INC, \quad (25.3)$$

$$p1labr_{jnp} = p1lab_{jrp} + xiitem_m, \quad r \in REG, n \in INC, p \in PRF, \quad (25.4)$$

$$p1lab_{rpj} = xi3 + flwag_{jrp}, \quad r \in REG, p \in PRF, j \in IND. \quad (25.5)$$

Block 26 Equations determining factor endowments by institution

$$ehoulab_{mp} = ulab_{jrp} + q_{mp}, \quad r \in REG, n \in INC, p \in PRF, \quad (26.1)$$

$$ehoucap_{mc} = ucap_{jc} + q_{pm}, \quad r \in REG, n \in INC, c \in CAP, \quad (26.2)$$

$$ehoulnd_{rnd} = ulnd_{jd} + q_{pm}, \quad r \in REG, n \in INC, d \in LND, \quad (26.3)$$

$$ecorcap_{oc} = ucap_{jc}, \quad o \in COR, c \in CAP, \quad (26.4)$$

$$ecorlnd_{od} = ulnd_{jod}, \quad o \in COR, d \in LND, \quad (26.5)$$

$$egovcap_c = ucap_{jc}, \quad c \in CAP, \quad (26.6)$$

$$egovlnd_d = ulnd_{jd}, \quad d \in LND, \quad (26.7)$$

$$erowcap_c = ucap_{jc}, \quad c \in CAP, \quad (26.8)$$

$$erowlnd_d = ulnd_{jd}, \quad d \in LND. \quad (26.9)$$

Block 27 Equations determining institutions' income by source

$$yhoulab_{mp} = ehoulab_{mp} + pllab_{jp}, \quad r \in REG, n \in INC, p \in PRF, (27.1)$$

$$yhoucap_{mc} = ehoucap_{mc} + plcap_{jc}, \quad r \in REG, n \in INC, c \in CAP, (27.2)$$

$$yhouInd_{md} = ehoulnd_{md} + plInd_{jd}, \quad r \in REG, n \in INC, d \in LND, (27.3)$$

$$ycorcap_{oc} = ecorcap_{oc} + plcap_{jc}, \quad o \in COR, c \in CAP, (27.4)$$

$$ycorInd_{od} = ecorInd_{od} + plInd_{jd}, \quad o \in COR, d \in LND, (27.5)$$

$$ygovcap_c = egovcap_c + plcap_{jc}, \quad c \in CAP, (27.6)$$

$$ygovInd_d = egovInd_d + plInd_{jd}, \quad d \in LND, (27.7)$$

$$yrowcap_c = erowcap_c + plcap_{jc}, \quad c \in CAP, (27.8)$$

$$yrowInd_d = erowInd_d + plInd_{jd}, \quad d \in LND, (27.9)$$

$$yhouhou_{muv} = fyhouhou_{muv} + yh_h, \quad r \in REG, n \in INC, u \in REG, v \in INC, (27.10)$$

$$yhoucor_{mo} = drate_o + ycor_o, \quad r \in REG, n \in INC, o \in COR, (27.11)$$

$$yhougov_m = fyhougov_m + ygov, \quad r \in REG, n \in INC, (27.12)$$

$$yhourow_m = fyhourow_m + phi, \quad r \in REG, n \in INC, (27.13)$$

$$ygovhou_m = tyhou_n + yhou_m, \quad r \in REG, n \in INC, (27.14)$$

$$ygovcor_o = tycor_o + ycor_o, \quad o \in COR. (27.15)$$

Block 28 Equations determining institution's income

$$\begin{aligned} yhou_m = \frac{1}{VYHOU_m} \big(& \sum_{p \in PRF} VYHOULAB_{mp} \times yhoulab_{mp} \\ & + \sum_{c \in CAP} VYHOUCAP_{mc} \times yhoucap_{mc} \\ & + \sum_{d \in LND} VYHOULND_{md} \times yhouInd_{md} \\ & + \sum_{o \in COR} VYHOU COR_{mo} \times yhoucor_{mo} \\ & + \sum_{u \in REG} \sum_{v \in P INC} VYHOUHOU_{muv} \times yhouhou_{muv} \\ & + YHOUGOV_m \times yhougov_m \\ & + VYHOUROW_m \times yhourow_m \big), \quad r \in REG, n \in INC, (28.1) \end{aligned}$$

$$y_{cor_o} = \frac{1}{VYCOR_o} \left(\sum_{c \in CAP} VYCORCAP_{oc} \times y_{corcap_{oc}} + \sum_{d \in LND} VYCORLND_{od} \times y_{corlnd_{od}} \right), \quad o \in COR, \quad (28.2)$$

$$y_{gov} = \frac{1}{VYGOV} \left(\sum_{c \in CAP} VYGOVCAP_c \times y_{govcap_c} + \sum_{d \in LND} VYGOVLND_d \times y_{govlnd_d} + \sum_{o \in COR} VYGOVCOR_o \times y_{govcor_o} + \sum_{r \in REG} \sum_{n \in INC} VYGOVHOU_{rn} \times y_{govhou_{rn}} + VYGOVTAX \times t0rev + V1OCT_j \times octrev \right). \quad (28.3)$$

Block 29 Equations of household expenditure and disposable income

$$y_{hou_{rn}} = \frac{1}{VYHOU_{rn}} \left(VYHOU_{rn} \times y_{hou_{rn}} - VYGOVHOU_{rn} \times y_{govhou_{rn}} - \sum_{u \in REG} \sum_{v \in INC} VYHOUHOU_{rn} \times y_{hou_{rn}} \right), \quad r \in REG, n \in INC, \quad (29.1)$$

$$y_{hou_{dr}} = y_{hou_{rn}} - xiitem_{rn}, \quad r \in REG, n \in INC, \quad (29.2)$$

$$chou_{rn} = y_{hou_{rn}} + apc_{rn}, \quad r \in REG, n \in INC. \quad (29.3)$$

Block 30 Equations for GNP and balance of payments

$$gnpexp = \frac{1}{GNPEXP} \left(VITEM_{km} \times chou_{rn} + PUR5_{is} \times oth + VSAV \times sav \right), \quad (30.1)$$

$$sav = \frac{1}{VSAV} \left(\sum_{o \in COR} VSAVCOR_o \times savcor_o + VSAVGOV \times savgov + \sum_{r \in REG} \sum_{n \in INC} VSAVHOU_{rn} \times savhou_{rn} \right), \quad (30.2)$$

$$gnpinc = \frac{1}{GNPINC} \left(GDPIN \times gdpinc + VNFI \times nfi \right), \quad (30.3)$$

$$nfi = \frac{1}{VNFI} \left(\sum_{r \in REG} \sum_{n \in INC} VYHOUROW_{rn} \times y_{hourow_{rn}} - \sum_{c \in CAP} VYROWCAP_c \times y_{rowcap_c} - \sum_{d \in LND} VYROWLND_d \times y_{rowlnd_d} \right), \quad (30.4)$$

$$1000 \times 100 \times \text{delLON} = \text{PUR2\_isj} \times \text{inv} - \text{VSAV} \times \text{sav} \tag{30.5}$$

Block 31 Equations of domestic savings by institutions

$$\text{yhou}_{\text{m}} = \frac{1}{\text{VHOUD}_{\text{m}}} \left(\text{VSAVHOU}_{\text{m}} \times \text{savhou}_{\text{m}} + \text{VITEM\_k}_{\text{m}} \times \text{chou}_{\text{m}} \right),$$

$r \in \text{REG}, n \in \text{INC}, (31.1)$

$$\text{ygov} = \frac{1}{\text{VYGOV}} \left(\text{VSAVGOV} \times \text{savgov} + \text{PUR5\_is} \times \text{oth} \right. \\ \left. + \text{VYHOUGOV}_{\text{m}} \times \text{yhougov}_{\text{m}} \right), \tag{31.2}$$

$$\text{ycor}_{\text{o}} = \frac{1}{\text{VYCOR}_{\text{o}}} \left(\text{VSAVCOR}_{\text{o}} \times \text{savcor}_{\text{o}} + \text{VYGOVCOR}_{\text{o}} \times \text{ygovcor}_{\text{o}} \right. \\ \left. + \sum_{r \in \text{REG}} \sum_{n \in \text{INC}} \text{SYHOUCOR}_{\text{rno}} \times \text{yhoucor}_{\text{rno}} \right),$$

$\text{o} \in \text{COR}. (31.3)$

Appendix D: Comparisons of Income and Expenditure Components of GDP in the Base-Year Data

The following table compares the expenditure given in *Pakistan Economic Survey* (GOP, 1989) with that in the Social Accounting Matrix (SAM). The final demand components: private consumption, public consumption and fixed capital formation in the SAM are exactly equal to the values given in the *Pakistan Economic Survey*. However, it appears that the total value of imports in SAM exceed those in the *Pakistan Economic Survey* by about Rs 15 billion. As a result the total expenditure on domestic commodities or the value of domestically produced goods from expenditure side in the SAM is less than that in the survey by about Rs 15 billion.

Table D1 Expenditure Accounts (Million Rs in 1983-84)

	<i>Pakistan Economic Survey</i>	Social Accounting Matrix	Difference
	1	2	3 (2-1)
Private consumption	341449	341449	0
Public consumption	50305	50305	0
Total consumption	391754	391754	0
Imports	92287	107377	-15090
Exports	47540	47540	0
Investments	63762	63762	0
Total Domestic Products	410769	395679	15090

On the income side, GDP at current factor cost in the SAM is lower by about Rs 24 billion. However, indirect taxes in the SAM are lower than those in the *Pakistan Economic Survey* (GOP, 1985) by about 2.4 billion. Thus total income — the sum of GDP at factor cost and net indirect taxes — in the SAM accounts are lower by about Rs 22 billion. The difference in the indirect taxes is due to net subsidies on exports of about Rs 1.3 billion and to subsidies of Rs 1.1

billion on petroleum products (see pages 34 and 43 in Dhanani(186a)). The export subsidies are not distinguished in the SAM as it is in purchasers' prices and thus contains F.O.B values of exports.

Table D2. Total Gross Domestic Products from Income Accounts in 1983-84
(Million Rupees)

	<i>Pakistan Economic Survey</i> 1	Social Accounting Matrix 2	Difference (2-1) 3
Value Added [†]	373656	349572	24084
Net Indirect Taxes	45396	47845	-2449
Total income	419052	397417	21635

† at current factor cost

In the national accounts there is a positive change in stocks of about Rs 8 billion as income is higher than consumption. However after balancing income and expenditure change in the stock value is only about Rs 1.7 billion. Thus the lower income of Rs 22.6 billion is made up by reducing domestic consumption by Rs 15 billion and reducing the inflow to stocks by Rs 6.6 billion.

Table D3. Balance of Gross Domestic Products from Income and Expenditure side
Million Rs (1983-84)

	1	2	3 (= 2-1)
	<i>Pakistan Economic Survey</i>	Social Accounting Matrix	Difference
Income	419052	397417	21635
Expenditure on domestic goods	410769	395679	15090
Stock change	8283	1738	6545

According to the *Pakistan Economic Survey* (GOP, 1985), out of total imports of Rs 92 billion (cost insurance and freight), Rs 76.6 billion is merchandise imports (Dhanani, 1986a, Table 3.12). The values of these imports

at market price were Rs 103 billion. The trade and transport margins, taken from the input-output table, were applied to arrive at imports flows at purchasers' prices. The trade and transport margins on imports, total Rs 15 billions, imply an average rate of 15 per cent. In the SAM there was a positive change of about Rs 1.7 billions compared to the stock change of Rs 8 billions given in the national accounts. Thus the lower value of GDP of Rs 21.3 billions was due to lower value of expenditure on domestic commodities by about Rs 15.0 billions and a lower value of stock change by about Rs 6.3 billions.

Appendix E: List of Industries, Commodities and Items

Table E1 List of Industries and their Sectoral Grouping

Industry No.	Industry Name
<i>Agriculture Sector</i>	
1	Wheat small-farms
2	Wheat large-farms
3	Rice small-farms
4	Rice large-farms
5	Cotton small-farms
6	Cotton large-farms
7	Sugarcane small-farms
8	Sugarcane large-farms
9	Tobacco
10	Oil seed and other cotton seeds
11	Pulses
12	Other crops
13	Livestock
14	Fishing
15	Forestry
<i>Oil & gas Sector</i>	
16	Oil and gas
<i>Large-scale Manufacturing Sector</i>	
17	Coal
18	Other minerals
19	Grain milling
20	Rice milling
21	Sugar refining
22	Edible oils
23	Tea blending
24	Fish and fish preparation
25	Confectionary and bakery
26	Other food industries
27	Beverages
28	Cigarettes and other tobacco
29	Cotton yarn
30	Cotton fabrics
31	Silk and synthetic textiles
32	Woollen textiles

... continued

Table E1 (continued)

Industry No.	Industry Name
33	Hosiery
34	Thread ball making
35	Carpets and rugs
36	Other textiles
37	Footwear other than rubbers
38	Wearing apparel
39	Wood, cork and furniture
40	Paper, paper board and products
41	Printing and publishing
42	Leather and products
43	Rubbers footwear
44	Other rubber products
45	Pharmaceutical and medicinal
47	Perfumes and cosmetics
48	Paints and varnishes
49	Soap and detergents
50	Matches
51	Other chemicals
52	Plastic products
55	Glass and products
56	Other non-metallic minerals
57	Basic metal
58	Metal products
59	Agricultural machinery
60	Other non-electrical machinery
61	Electric machinery
62	Bicycles
63	Auto assembly and parts
64	Ship building
65	Cotton ginning
66	Office equipment
67	Sports goods
68	Surgical instruments
69	Other large scale manufacturing
	<i>Fertiliser Sector</i>
46	Fertiliser

... continued

Table E1 (continued)

Industry No.	Industry Name
	<i>Refiner Sector</i>
53	Refinery (oil refining)
	<i>Cement Sector</i>
54	Cement
	<i>Small-scale Manufacturing Sector</i>
70	Small-Scale grain milling
71	Small-Scale rice husking
72	Small-Scale gur and raw sugar
73	Small-Scale edible oils
74	Small-Scale other food industries
75	Small-Scale beverages
76	Small-Scale tobacco
77	Small-Scale cotton textile
78	Small-Scale silk and art-silk textiles
79	Small-Scale carpets
80	Small-Scale other textiles
81	Small-Scale shoe making
82	Small-Scale wood
83	Small-Scale furniture,
84	Small-Scale steel furniture
85	Small-Scale printing and publishing
86	Small-Scale leather products
87	Small-Scale rubbers goods
88	Small-Scale chemical
89	Small-Scale plastic products
90	Small-Scale non-metallic minerals products
91	Small-Scale iron and steel remoulding
92	Small-Scale metal products
93	Small-Scale agricultural machinery
94	Small-Scale non-electrical machinery
95	Small-Scale electric machinery
96	Small-Scale transport equipment

... continued

Table E1 (continued)

Industry No.	Industry Name
97	Small-Scale sports goods
98	Small-Scale surgical instruments
99	Other small scale manufacturing
	<i>Services Sector</i>
100	Low cost residential building
101	Luxurious building
102	Rural building
103	Factory building
104	Public building
105	Roads
106	Infrastructures
107	Ownership of dwelling
113	Whole sale and retail trade
114	Road transportation
115	Rail transportation
116	Air transportation
117	Water transportation
118	Television
119	Radio
120	Telephone
121	Banking
122	Government services
123	Services not elsewhere specified
	<i>Natural Gas Sector</i>
112	Natural gas (gas refining)
	<i>Electricity Sector</i>
108	Hydro power
109	Combined cycle
110	Steam plants
111	Gas turbines
	<i>Non-Competing Imports Industries[†]</i>
124	Other transport
125	Air transport
126	Insurance
127	Government
128	Other services

[†] These industries produce no products.

Table E2 List of Commodities

Commo- dity No.	Commodity Name
1	Wheat (Small-farms)
2	Wheat (Large-farms)
3	Rice (Small-farms)
4	Rice (Large-farms)
5	Cotton (Small-farms)
6	Cotton (Large-farms)
7	Sugarcane (Small-farms)
8	Sugarcane (Large-farms)
9	Tobacco
10	Oil seed and other cotton seeds
11	Pulses
12	Other crops
13	Livestock
14	Fishing
15	Forestry
16	Oil
17	Gas
18	Coal
19	Other minerals
20	Grain milling
21	Rice milling
22	Sugar refining
23	Edible oils
24	Tea blending
25	Fish and Fish preparation
26	Confectionary and bakery
27	Other food industries
28	Beverages
29	Cigarettes and other tobacco
30	Cotton yarn
31	Cotton fabrics
32	Silk and synthetic textiles
33	Woollen textiles
34	Hosiery
35	Thread ball making
36	Carpets and rugs
37	Other textiles

... continued

Table E2 (continued)

Commodity No.	Commodity Name
38	Footwear other than rubbers
39	Wearing apparel
40	Wood
41	Paper
42	Printing and publishing
43	Leather and products
44	Rubbers footwear
45	Other rubber products
46	Pharmaceutical and medicinal
47	Fertiliser
48	Perfumes and cosmetics
49	Paints and varnishes
50	Soap and detergents
51	Matches
52	Other chemicals
53	Plastic products
54	Kerosene
55	High speed diesel
56	Light speed diesel
57	Gasoline
58	Furnace oil
59	Other petroleum products
60	Cements
61	Glass and products
62	Other non-metallic minerals
63	Basic metal
64	Metal products
65	Agricultural machinery
66	Other non-electrical machinery
67	Electric machinery
68	Bicycles
69	Auto assembly and parts
70	Ship building
71	Cotton ginning
72	Office equipment

... continued

Table E2 (continued)

Commodity No.	Commodity Name
73	Sports goods
74	Surgical instruments
75	Other large scale manufacturing
76	Small-Scale grain milling
77	Small-Scale rice husking
78	Small-Scale gur and raw sugar
79	Small-Scale edible oils
80	Small-Scale other food industries
81	Small-Scale beverages
82	Small-Scale tobacco
83	Small-Scale cotton textile
84	Small-Scale silk and art-silk textiles
85	Small-Scale carpets
86	Small-Scale other textiles
87	Small-Scale shoe making
88	Small-Scale wood
89	Small-Scale furniture
90	Small-Scale steel furniture
91	Small-Scale printing and publishing
92	Small-Scale leather products
93	Small-Scale rubbers goods
94	Small-Scale chemical
95	Small-Scale plastic products
96	Small-Scale non-metallic minerals products
97	Small-Scale iron and steel remoulding
98	Small-Scale metal products
99	Small-Scale agricultural machinery
100	Small-Scale non-electrical machinery
101	Small-Scale electric machinery
102	Small-Scale transport equipment
103	Small-Scale sports goods
104	Small-Scale surgical instruments
105	Other small scale manufacturing
106	Low-cost residential building
107	Luxurious building
108	Rural building

... continued

Table E2 (continued)

Commodity No.	Commodity Name
109	Factory building
110	Public building
111	Roads
112	Infrastructures
113	Ownership of dwelling
114	Electricity
115	Natural gas (gas refining)
116	Whole sale and retail trade
117	Road transportation
118	Rail transportation
119	Air transportation
120	Water transportation
121	Television
122	Radio
123	Telephone
124	Banking
125	Government services
126	Services not elsewhere specified
	<i>Non-Competing Imports Commodities[†]</i>
127	Other transport
128	Air transport
129	Insurance
130	Government
131	Other services

[†] These commodities have no domestic substitutes.

Table E3 List of Item Names

Item No.	Item Names
1	Wheat
2	Rice
3	Other cereals
4	Pulses
5	Milk products
6	Edible oils
7	Meat
8	Fish
9	Fruits
10	Vegetables
11	Spices
12	Mill sugar
13	Gur and other sugar
14	Tea
15	Cigarettes
16	Cigars
17	Pan and accessories
18	Other tobacco
19	Miscellaneous food
20	Cloth
21	Garments
22	Household textiles
23	Footwear
24	Personal effects
25	Dung-cake
26	Kerosene
27	Charcoal
28	Coal
29	Natural gas
30	Electricity
31	Matches
32	Other fuels
33	Rent
34	Rent free accommodation
35	Owner occupied house
36	Repair and improvement

...continued

Table E3 (continued)

Item No.	Item Name
37	Water and other charges
38	Other house expenses
39	Furniture and fixtures
40	Kitchen equipment
41	Crockery and cutlery
42	Other household effects
43	Personal care
44	Medical care
45	Education
46	Recreation durable
47	Recreation non-durable
48	Transport equipment
49	Transport non-durable
50	Telephone and telegraph
51	Laundry
52	Domestic help
53	All other items

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