

I N V E N T I O N S A N D E C O N O M I C

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I. Introduction.

In the long run, technical progress is undoubtedly the most important factor of economic growth - whether the latter means an increase in the aggregate real income or one in the per-capita real income of a community. In the absence of technical advance economic growth would be possible only at a much lower rate and within rather narrow limits.

Of course, should the progress in technical knowledge come to a standstill at this very moment, economic growth could go on practically undisturbed for some time, perhaps for years, but soon enough it would necessarily slacken, and would probably completely stop in the end. Up to a point, the real income of any country could be increased by a mere re-allocation of existing resources on the basis of existing knowledge without any additional net investment - that is by different rationalization methods (especially by fuller utilization of existing production capacities). A further growth could be achieved by an increase in the working hours and in the working intensity of the population and by investing additional capital in productive equipment, in the development of natural resources and in the training of the labour force. An increase of population could also raise the per-capita income in the few scarcely populated countries of the world, and could increase the aggregate income in nearly all (if only at the price of reducing at the same time the per-capita income).

But, in the absence of a further progress in technical knowledge, probably neither the per-capita, nor the aggregate real income of a country could be raised by these factors

above a certain maximum.(Of course,in this case economic growth would still have a considerable scope in backward countries, which utilize even the existing technical possibilities very incompletely. Advanced countries,however, could achieve very little further economic advance without additional technical progress).

This proposition is quite obviously true if we accept the theory that the amount of capital that can be profitably invested at any given level of technology is limited, i.e. that the increments in aggregate income due to the investment of successive additional doses of capital fall eventually to nil. [¶] But even under the opposite assumption,it can hardly be doubted that these increments form a quickly decreasing (even if infinite) series beyond a certain point and it seems reasonable to assume that their sum is convergent,i.e. remains below a certain limit.

What is more, in the absence of further technical progress,not only the growth in the real income of any country would be limited, but this income could not even be maintained indefinitely at its present level, owing to the gradual using-up of natural resources. (Even given further technical progress,there is no guarantee that the future

[¶] For the controversy on the possibility of profitably investing unlimited amounts of capital at a given state of technical knowledge, see F.H.Knight, "The Quantity of Capital and the Rate of Interest", Parts I-II, Journ.of Pol.Ec.,1936. Idem, "Diminishing Returns from Investment", Journ.of Pol.Ec., 1944. O.Lange, "Interest in the Theory of Production", Rev. of Ec.Stud.,1936. F.H.Knight,"Note on Dr.Lange's Interest Theory", and Prof.Lange's reply, both in Rev.of Ec.Stud.,1937. D.McC.Wright, The Economics of Disturbance, New York,1947, pp.46-59.

exhaustion of natural resources will possibly be made up for by new inventions in due time. We still live in a world in which there is a so far undecided race between the waste of natural resources and the advance of science.)

But, however great the importance of the factor of technical advance in economic growth, this factor itself is in turn governed, to a large extent, by economic forces.

Of course, technical progress would probably go on at some rate even if inventions had no commercial value whatever. Some chance discoveries would occur even in this case and some research work would be undertaken out of pure scientific curiosity. But the present rate of technical progress is far above this "spontaneous" rate and can be maintained only by the expenditure of substantial economic resources on research, for economic (and military) considerations. In this respect inventing is similar to other human activities of economic importance, in all of which, also, there would be some supply forthcoming even in the absence of any economic incentive, but of which the actual supply is due, to a large extent, to economic forces only.

Economic motives, at least the desire to facilitate one's own work or to make it more productive, must have underlain many inventions of the earliest times. But historians claim that a number of the earliest inventions of great economic significance were due, not to utilitarian, but rather to religious, magical or artistic motives.[‡] In fact, it is quite likely that technical progress would have been slower still in primitive times, if the man of that time had only experimented with devices the economic usefulness of which he could foresee with his then given limited knowledge.

But, at least since the beginning of the modern age, economic forces have played an ever increasing part in tech-

[‡] See, for instance, E. Hahn, *Das Alter der wirtschaftlichen Kultur*. (How Old is the Economic Aspect of Culture?) For Place and Year of publication of the books quoted see Bibliography (pp. 95-8).

nical progress, though mere chance or pure scientific curiosity have still been important factors. (Moreover, from time to time, military considerations have gained predominance over the economic.) Even the independent inventor has very often been motivated by the hope of pecuniary gain, and this is even truer about his financial backers.

But in the last few decades the invention-producing "industry", as it were, has undergone a revolutionary re-organization - which may prove one of the most important institutional changes in our economic system. The independent inventor has been replaced, to a great extent, by the large-scale research laboratory. Moreover, the capital-intensity per research worker of this "industry" has greatly increased owing to the need for more expensive equipment and to the lengthening of the time needed on the average for completing a research project. At the same time, a kind of "vertical integration" has taken place: many firms have undertaken to finance the development of the inventions they need, instead of waiting for their emergence out of the workshop of the independent inventor. Or, alternatively, research has been socialized in some fields, governments taking over the responsibility for it.

These developments have subjected technical progress to the influence of economic forces even more. Whatever the personal motives of the research worker, he is employed and is given expensive equipment for economic (or military) reasons. He may be left some freedom, but, after all, he has to produce, as far as possible, the inventions his employer needs and finds worth their development costs. Thus economic forces have come to govern, not only the rate of technical progress, but also its direction, to an ever growing extent.

But, of course, they cannot mould them at will. However high the demand price that the solution of a certain technical

problem could command, it may still be insoluble for the time being, or may be soluble only at prohibitive cost. The forces of demand cannot decide the outcome by themselves, independently of the forces of supply - in this field any more than in any other.

The old-fashioned social philosophers usually lost their way at this point when speculating about the "laws" of technical progress. They either considered only the factors underlying the supply of inventions and regarded technological progress as an autonomous process following laws of its own - or, alternatively, looked only to the forces of demand and spoke as if social needs necessarily called forth the inventions gratifying them.

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The emergence of the research laboratory maintained by a business firm makes necessary the revision of the Schumpeterian view on the entrepreneur's role in technical progress. (Schumpeter himself freely admitted the importance of this new factor in his later works.) Schumpeter^(has) put great stress on the fact that technical progress is not the automatic result of the emergence of new inventions as such - for the mere existence of new inventions does not mean their practical adoption. There are psychological and sociological reasons for this, but, from an economical standpoint, the main reason is the risk involved in the introduction of a new invention. Therefore, the introduction of new inventions - just as well as of other innovations - requires a special agent, viz. the entrepreneur. This may be the inventor himself, but need not be - in effect, this is less often the case than the opposite. It is more commonly found that entrepreneurs have primarily a commercial background than that they have a technical one.

Accordingly, Schumpeter conceived the entrepreneur as a business man who puts existing inventions into practice (or who makes other kinds of innovations), but who has nothing to do with the production of new inventions - except, indeed, if he happens to be the inventor himself. On the contrary, the new type of entrepreneur (whether the head of a private firm or the manager of a joint-stock company) undertakes the financing of the development of new inventions just as much as the financing of the production of material commodities - though, for reasons we shall consider below (see p. 43) he is usually interested only in the development of inventions he intends to use himself and does not produce inventions for the market. The financing of research projects - a most hazardous and unpredictable venture, which involves great risks both of a technical and a commercial nature requires entrepreneurial qualities of the highest order. (It may be noted that even the old-fashioned independent inventor, if he undertook inventing for the sake of monetary gain, must be considered as a small entrepreneur.)

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Owing to the increasing importance of industrial research in business life, it is highly desirable to extend economic analysis to this field. Originally, economic science dealt only with exchange and production, since business life consisted mainly of these two activities. (The theory of distribution is only an application of the general theory of exchange and production, while consumption is discussed by the economist only as far as it is needed for the purposes of analysing exchange and production.) Recently advertising has had to be added, as it had become one of the most important activities of the business man. Now, for similar reasons, industrial research must also be admitted into economic science.

It will, however, be argued in the Appendix of this Essay (see p. 81) that the application of the analytical methods of economic science could be profitably extended to still further fields - that is to say, to some human activities without any particular institutional connection with business life, which have been traditionally assigned to other social sciences for investigation, for instance to some problems of political science or of sociology.

The application of economic analysis to a new field always poses two fundamental questions. In the first place, what laws govern the "costs of production", (in terms of effort, of money, and of other resources) of certain results - e.g. "the costs of production" of new consumption-habits (in the case of advertising), or of new inventions, or of new associations, or of political power etc. Or, to put it in another way, what results can be achieved in the field under investigation - in advertising, or in industrial research, or in organizing new associations, or in political life etc. - by the expenditure of different amounts of effort, of money or of other resources. (This could be called the problem of "supply".) In the second place, what laws determine the amount of effort, of money and of other resources that the members of the community are ready to spend on the production of these results, - on advertising, or on research, or on organizing associations, or on political goals etc. (This may be called the problem of "demand".)

Of course, the "costs of production" of consumption-habits, of inventions, of associations or of political power each follow different laws and none of these is identical with the laws determining the costs of production of material commodities. Likewise, the laws of demand are also different in each field. The main task of the economic analysis of these different human activities would be the discovery of these special economic laws of each of them.

II. The Development Costs of an Invention.

The development of an invention starts with somebody's conceiving the idea that there is a demand for the solution of a certain technical problem (whether this demand is manifest or exists only in a latent state) and that there is a hope that this solution may be found in a certain particular way. The task of industrial research is to develop this preliminary idea up to the stage of practical usefulness. It has to find out whether this idea is practicable at all, and which of the conceivable alternative solutions is the most appropriate.

The development of a research project involves, apart from a certain amount of auxiliary activities (such as looking up the relevant literature, planning the work, calculating, designing etc.), mainly experimentation. The development costs of such a project depend, hence, chiefly upon the number of the experiments needed and upon the average unit costs of these experiments.

The number of experiments needed tends to be roughly proportional to the number of the possible alternative solutions of technical problem(s) involved, since in principle all of them have to be tried out. This number may be called the *d e g r e e o f v a g u e n e s s* of the research project. (Actually, more experiments may be necessary than this, since usually each of the experiments has to be repeated more than once to make sure that the result is reliable; or, on the contrary, fewer experiments may suffice, since the right solution may be found long before all the conceivable solutions have actually been tested.)

For some technical problems the degree of vagueness may have the value of one, i.e. they may suggest only one solution. If this one happens to prove a failure, it may be impossible for the time being to devise any alternative approach. For other

technical problems this parameter may have a value as high as several thousands, as the number of possible solutions may be as large as that - for instance if a material with certain required properties has to be selected out of a large chemical group.

One of the factors determining the degree of vagueness of a research project is the number of technical problems involved (further not divisible) that require solution if the resulting invention is to be a practical success. This number may be called the degree of complexity of the research project. The greater the number of the constituent parts of a devised appliance, or the greater the number of the part processes involved in a devised production process, the higher this figure tends to be. At the same time, special technical problems may be connected not only with the production of a certain commodity, but also with its use, transportation, control, maintenance, repair etc., all of which problems enter into the degree of complexity of the corresponding research project.

The degree of vagueness of a complex research project is the sum of the degrees of vagueness of the part problems involved if the solution of any part problem is independent of that of any other. If, on the contrary, all these part problems are interdependent, then any possible combination of the alternative solutions of each part problem must be taken into account, and the degree of vagueness of the whole project is equal to the product of the degrees of vagueness of all the part problems. Other cases are intermediate between these two.

The degrees of vagueness of research projects in a certain field tend to vary with the progress in our knowledge about it. When the exploration of a particular field has only just started, technical problems arising in it tend to have a low degree of vagueness. For, if we are at all able to suggest solutions for them, we are hardly in the position to suggest more than very few tentative solutions. At a later stage, the degree of vagueness of the average research project in the same field tends to be higher, since the number of alternative solutions that can possibly be thought out tends to be larger. At a still later stage, however, this degree of vagueness tends to diminish once more, as we come to be able to select the few most promising alternatives out of the great number of devisable possibilities. At last, the solution of a technical problem in a particular field becomes a mere routine engineering problem, a matter of simple application of established rules - which is now the case, for instance, in some branches of mechanical engineering or of organic chemistry. Usually one solution only is to be tested in these fields, i.e. the degree of vagueness of most problems is only one.

Besides the number of experiments needed, the other main factor determining the development costs of a research project is the average unit cost of an experiment.

The continuous progress in experimental methods tends to reduce this cost in any given field of technology. At the same time, however, as the old fields of research become more and more explored and come to show decreasing returns, the center of gravity of industrial research tends to shift to new fields in which the costs of experiments are higher owing to experimental conditions less easy to produce, such as very high or very low temperatures or pressures, very high voltages or

or frequencies etc. (While research in a given field may easily show decreasing returns after a certain point, there is no sign of research in general showing decreasing returns, since the new fields seem to be at least as profitable as the old were. They tend to entail higher research costs, but also to yield a proportionate return.)

This increase in the unit costs of an experiment is one of the reasons for the obvious fact that the development costs of really important research projects tend to increase on the average from decade to decade. The other reason is the growing willingness to attack research projects "less ripe" for solution yet, which require a larger number of experiments (i.e. have a higher degree of vagueness), instead of waiting until the advance in our knowledge reduces this number.

This increasing readiness itself to undertake large-scale research projects is probably due to the growing size of firms and to the general tendency towards government intervention manifested also in the increase of the endowment of government research organizations (and to military considerations).

The costs of research include, of course, allowances for the physical depreciation and the obsolescence of the research equipment, and interest costs. In spite of the recent increase already mentioned in the capital intensity per research worker of research, interest costs are still a fairly small item, at least in the case of ordinary industrial research, where few projects take more than 1-2 years to complete. [‡] (Of course, fundamental research, of which the practical fruits may come only after decades, is rather different.)

[‡] C.C. Furnas, Research in Industry, p. 111.

Mr. C. C. Furnas has found that the median percentage of the total research costs spent on salaries and wages was as high as 68% (in a sample of 51 U.S. firms),^{*} which is comparable with the labour costs of industries that have a rather low capital intensity. Of course, one of the reasons for these high labour costs is the relatively high rate of pay of the research staff.

A realistic cost-accounting must make a considerable allowance for risks in the case of research. Large firms can expect that the Law of Large Numbers will roughly cancel out chance fluctuations in successes and failures. They may simply require that the successful projects should pay for themselves, and also for the failures, on the average. This means that, if the probability of the success of a given project is p , then the costs of $(1-p)$ failures must be borne by p successful projects, i.e. each of the successful projects must be debited with a $\frac{1-p}{p}$ part of its total costs as an actuarial risk premium. Let stand C for these total costs. Then $C + \frac{1-p}{p} \cdot C = \frac{C}{p}$, which is the amount of the total costs of the project with the inclusion of the actuarial risk premium.

Small firms must reckon with the possibility of uncompensated substantial net gains or losses. This possibility may be considered as a source of extra net utility or disutility, according to the subjective attitude of the firm towards risk-taking, which justifies an addition to, or a subtraction from, the actuarial risk premium.

^{*} O.c. p. 149.

Though this principle is clear enough, its application is not easy, since p , the numerical probability of the success of a research project, is very hard to estimate. We must start from the frequency of the success of similar research projects in the same field as observed in the past.[‡] But it is always difficult to decide whether a given project has a higher or a lower probability of success than the average of its class.

Allowance must be made not only for the risk of the complete failure of the project, but also for its entailing much higher costs than originally estimated, owing to unexpected technical difficulties, i.e. to the emergence of additional technical problems, which increase the degree of complexity and, consequently, the degree of vagueness of the project as well.

Besides these technical risks, there is also the commercial risk that the resulting invention may turn out to be of a much lower commercial value than expected, because competitors succeed in bringing out a similar or even a better invention, perhaps at a prior date, or because other changes occur in the market conditions.

Ideas for new inventions that can serve as a basis for promising research projects are often available free of cost. In many cases, however, it has been found profitable to encourage their emergence by special measures, the costs of which enter, of course, in the production costs of new inventions.

An idea for a new invention is based upon realizing the connection between certain scientific facts (i.e. properties of the inanimate, animate and human universe) and between a certain human need, viz. that these facts can be utilized for the satisfaction of this need. Consequently, the emergence of such ideas can be promoted in three ways.

[‡] According to Mr. D. B. Hertz, the average chance of success for a research project is usually estimated at 10-50%, depending on industry. See his *The Theory and Practice of Industrial Research*, p. 213.

In the first place, special measures may be undertaken to find out those technical problems the solution of which would meet important practical needs. For instance, some firms require that their sales department should carefully register any complaint against quality and their production department any trouble in the production process, in order to ascertain in what respects the products and the production methods of the firm need improvement. (Of course, similar information about other firms would also be of great value, but is usually hard to obtain.)

In the second place, special steps may be taken to bring together the knowledge of practical needs and the knowledge of scientific facts, possibly of facts belonging to the fields of several different sciences. This may be done by training one and the same person in different sciences and making it possible for him to gain experience also in some practical positions. Or, it may be done by the organized cooperation of different kinds of scientists and of practical men.

The most important method, however, for stimulating the emergence of ideas for new inventions is financing the discovery of new scientific facts, i.e. fundamental research. This is hardly profitable for a small firm, but is important in the case of a large firm or a government research organization. Whenever the rate of applied research is greatly increased in a certain field, decreasing returns can be avoided only by a parallel extension of fundamental research. For, otherwise the promising practical applications of known facts would be explored by applied research at a higher rate than new facts were discovered by fundamental research, and the

former would have to turn towards projects of lower value. ‡

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The average development costs of new inventions of a given value or, in other words, the productivity of research, is subject to violent fluctuations in any particular field of technology over a period of time, for it depends on the quantity and quality of ideas for new inventions, which is a highly unstable factor.

‡ The question may be raised whether increases in research expenditure could indefinitely avoid decreasing returns if the right ratio between applied and fundamental research were maintained.

In any case, research in general does not meet decreasing returns for the same reason as research in a special field often does, viz. because the exploration of the relevant field becomes more and more complete and leaves little room for further discoveries. In effect, the universe as a whole is still explored only to a negligible extent.

Decreasing returns are, however, likely to emerge eventually on two accounts. In the first place, fundamental research - in contrast to applied research - is an "industry" with a high intensity of capital, since its practical fruits tend to appear after a considerable "gestation period". Consequently, a substantial increase in the expenditure on fundamental research (or a parallel increase both in fundamental and in applied research) would soon run up against the scarcity of capital, even in countries rich in capital.

In the second place, as we shall see below, the number of inventions that a firm (or an industry or even the whole economy) can use in each period is limited. If this limit is approached, the economic value of additional inventions tends to diminish rather quickly.

After the discovery of an important new fact, or of a relation between known facts, or of a new practical application of existing knowledge, ideas worth developing tend to be abundant and promising a high return. But after this wave of ideas has been used up, stagnation may follow for a considerable period.

In spite of the fact that scientific and technical research tends to become more and more an organized methodical activity, the discoveries initiating an epoch of great advance are still very often the result of chance or of an unexpected spurt of genius. Facts of which the existence was by no means surmised before they have actually been discovered, obviously cannot be found by methodical effort at all. * Whatever the limits to man's possible control over nature, clearly his possibilities in controlling his own scientific and technical progress do have definite limits.

Of course, a period of quick technological advance in a certain field stimulates inventing, not only on the part of supply, i.e. by making inventing easier, but also on the part of demand, viz. by creating a demand for economically complementary inventions to the inventions recently made in this field.

* At the same time, these very chance discoveries are often a spontaneous by-product of scientific research. An increase in the volume of fundamental research tends to involve, not only a quicker following-up of the implications of known facts, but also an increase in the rate of the chance discovery of completely new facts. Fundamental research itself tends to take care of the replacement of the raw material of facts which it is using up, while applied research only subsists on a raw material of ideas furnished by fundamental research.

For instance, the invention of the internal-combustion motor stimulated not only the invention of different applications for this principle, but also the invention of new oil-refining methods and of new types of brakes. The fluctuation in the rate of inventing in any particular field found by Professor R.K. Merton is the effect of both forces at once. [ⓧ]

[ⓧ] See his "Fluctuations in the Rate of Invention", Quart.Journ. of Econ., 1935.

III. The Profitability of Innovations
and the Value of Inventions for the Firm.

A firm can usually make higher profits by innovating than by not innovating, and can make higher profits by adopting new inventions than by other kinds of innovations.

In a largely stationary economy the profits of non-innovating firms would tend to fall to the normal supply price of management, except for fields in which indivisibilities or goodwill tended to secure a monopoly position and monopoly profits for the first-comers. In every other fields over-normal profits could be earned only by establishing a temporary monopoly position through innovating. In a dynamic economy like ours, however, in the long run probably even normal profits can be earned only by innovating, and over-normal profits tend to result only from innovating to an over-normal extent and with an over-normal skill.

The adoption of new inventions tend to bring in higher profits than other innovations for two reasons.

On the one hand, it may make possible larger cost reductions, greater improvements in quality and more attractive new products than would be feasible without the use of new inventions. (Fundamentally, every invention may be regarded as cost-reducing. This is so because those inventions that improve quality reduce the costs of this higher quality, and those resulting in a new product reduce the costs of this new product - possibly from infinity to a finite figure if previously this quality or this product could not have been produced at all.)

On the other hand, the adoption of new inventions may secure a higher and longer protection against competition, owing to patent rights, to the possibility of secrecy or to a larger period of construction required for a novel type of equipment embodying a new invention.

The demand price (use value) of an invention for the firm intending to adopt it is equal to the discounted present value of the additional profits expected from it.

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Firms may, however, buy the patent right or the secret of a new invention, not only in order to use it, but also in order to suppress it. The demand price they would be ready to pay for its suppression may be called the suppression value of the invention. It tends to be equal to the discounted present value of the losses resulting to the firm from the fact that somebody else puts this invention into use, multiplied by the probability of this happening.

The purchase of inventions for suppressing them can be profitable only if their use value for their present owner is less than their suppression value is for the buyer. This position may be due, of course, simply to the fact that the present owner lacks the means for making a good use of the invention and, on account of the imperfections of the market for capital and of the market for inventions, is unable to have access to those who would have the means required.

But, even if an invention is in the possession of the very firm which can make the largest profits at all possible on it, these profits may be still less than

the loss of its competitors or, to put it in another way, the introduction of this invention may have the effect of reducing the joint profits of the whole industry. There is an output of a certain size and of a certain quality of the industry which maximizes these joint profits. Whenever the adoption of a new invention tends to increase the output of the industry, or to improve its quality, beyond this monopolistic "optimum" point, it will always reduce the joint profits of the industry and its suppression value will be higher than its use value.

From a social standpoint, of course, there is no special advantage connected with keeping the output of an industry at the point of joint-profit maximization, and the suppression of inventions is in general against the social interest. But this is not always so. If a new invention only tends to increase "irrational" product differentiation in the Chamberlinian sense, or if the possibility of suppressing competitive inventions is the condition for certain socially desirable investments being undertaken at all, then the suppression of certain inventions may be justifiable. (Of course, the patent laws of some countries, especially of the United States, may actually give too much opportunity for suppressing inventions.)

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The modern theory of the firm considers every firm as a monopolist on its own product markets and as a monopsonist on its own factor markets. Perfect competition is regarded only as a limiting case. The behaviour of the firm, however, cannot be fully understood on the

basis of the classical theory of monopoly, as the special markets of the different firms are interdependent (moreover there may be a bilateral monopoly on some markets). A really satisfactory theory ought to be a theory of the general equilibrium of an imperfectly competitive economy. As such a theory has not been developed yet beyond an initial stage, a new type of particular equilibrium analysis has been devised as a kind of second-best solution, which uses, instead of the Marshallian curves of demand for products and of supply of factors, based on the assumption of constant prices elsewhere in the economic system, new sorts of demand and supply curves discounted for the effects of the counter-moves of other firms and possibly also for the reactions on the part of other factors. These we shall call curves "discounted for repercussions". (Mr. Kaldor likes to call them "imagined" curves. However we need, it seems to me, a term applicable to them whether they are "imagined" or "real", as distinguished from the Marshallian curves based on the assumption of constant prices elsewhere, which may equally be also "imagined" or "real".)

Usually allowance is made for the competitor's immediate reactions only when these curves are drawn. But some reactions of other (existing or not yet existing) firms need time to develop, if they are to develop at all. These reactions are meant by the term "potential competition" (perhaps the term "lagged competition" would better express what is really meant.). We propose to deduct from the total-revenue curve of the firm the present value of the losses expected to result from this potential competition as well, since the firm does take them into

account, and makes its marginal cost and its marginal revenue equal only after this allowance has been made.

Similarly, an ^{increment}rise in the costs of the firm which is due not to a change in the amount of the factor services bought by the firm, but rather to a change in ^{its}the pricing and output policy, ~~of the firm~~, can be best allowed for by deducting it from the revenue of the firm, since it cannot be represented by a movement along one and the same cost curve. This applies, for instance, to a rise in the firm's costs due to an alteration in the government's taxation (or even nationalization) policy, or in the trade unions' wages policy towards the firm in response to changes in the firm's pricing or output policy.

On the contrary, repercussions on the part of the government and of the trade unions, not to the pricing and output policy of the firm, but rather to its factor hiring policy (including its technical production policy), should be included in its cost curve. For example, additional costs due to the trade unions' resistance against a reduction in the staff may well be included in the shape of the firm's cost curves.

Finally, repercussions to the firm's sales promotion policy may be included in its sales costs.

The present sales policy of the firm also affects its future sales by its effects on the consumers' goodwill, stocks, and "saturation" with the products of the firm. These losses and gains must also be allowed for in the revenue curves.

The average revenue curve discounted for all these repercussions is, of course, no longer identical with the demand curve.

Uncertainty can be taken into account by Professor Lange's method based on the risk-indifference map of the firm.

Within this conceptual framework the recently much emphasized observation that firms hardly ever exploit fully their monopoly positions (for fear of potential competition, of the reactions of the Government etc.) can be replaced by the proposition that the average revenue curves of the firms - if fully discounted for all the repercussions - are considerably less elastic than their average revenue (demand) curves discounted only for the immediate reactions of their actual competitors, which fact well explains the lower profit margins actually observed. (Of course, the same fact tends to lower the use value of new inventions for them, which comes on the other side of the balance-sheet from a social standpoint.)

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Let us consider first the case of a firm which makes no use of sales promotion and which does not introduce new products. The innovations of such a firm can consist only in the adoption of new methods for producing products already produced. Such an innovation can be profitable only if it reduces the costs of producing outputs of a certain size. If it reduces the costs of producing the old output, it cannot fail to be profitable, but it may pay also if it reduces the costs of producing larger or smaller outputs sufficiently, though at the same time increasing the costs of producing the old output.

Professor Lange has shown that innovations which increase the marginal cost at the level of the old (Optimum) output tend to reduce the volume of production, and those which decrease this marginal cost tend to increase the output

of the firm. This means that innovations that increase the efficiency of production at higher outputs more than at lower outputs, are output-increasing and vice versa.

We shall make the simplifying assumption that variable unit costs are constant both before and after the innovation (which is a quite realistic assumption until the output does not exceed the normal capacity of the plant). Then all innovations that reduce the variable unit cost are output-increasing (whether they increase or reduce fixed costs). Those which reduce fixed costs, but increase the variable unit cost are output-decreasing. Innovations that would increase both variable and fixed costs cannot be profitable. [ⓧ]

[ⓧ] The firm makes its decisions about the introduction of a new method of production on the basis of "avoidable" (not yet incurred) costs alone. The "irrevokable" fixed costs of the old equipment must be disregarded and only the variable and maintenance costs entailed by it must be counted. On the other hand, the net fixed costs of the new equipment must be reckoned with allowance being made for those parts of the old equipment that can be retained in use along with the new process, and for the scrap value of the other parts.

It is often said that the immediate introduction of a new method (involving the scapping of the old equipment) is profitable if, and only if, the total costs with the new equipment are less than the variable and maintenance costs with the old. In reality, this proposition is true only if the firm produces an output of the same size with the new method as it did with the old.

Of course, if the new method is profitable with this old output, it must pay also with the output best adapted in size to the new conditions (since the latter is, by definition,

(Continued on next page.)

use value of an invention
The ~~surplus profits of an innovation~~ that leaves the output unaltered is simply the capitalized value of the savings in total costs. It is, of course, an increasing function of the percentage saving in the unit cost, of the absolute size of this unit cost, and of the output. Other things being equal, a cost-reducing invention tends to have a higher use value the greater the output and the larger the production costs of the commodity with which it is connected. This implies that large firms with a high output tend to have a higher use value for an invention.

In the case of output-increasing or decreasing innovations the elasticity of the average revenue curve may be decisive as to whether an innovation is profitable or not.

(Continued from p.24.)

even more profitable). However, this is only a sufficient, but not also a necessary, condition. The immediate adoption of the new method may be profitable for producing a larger output, even if it is not profitable for producing the old one.

It should be said more correctly that the discarding of the old equipment is worth while if, and only if, the net profits with the new method (after deducting the net fixed costs of the new equipment) are higher than the gross profits with the old method (without deducting the fixed costs of the old equipment) would be. This formulation makes the profit formula on p. 27 immediately applicable to this case.

This implies, however, that the position greatly depends upon the elasticity of the demand curve for the

(Continued on next page.)

Let stand p_1 and p_2 for the old and the new price respectively, q_1 and q_2 for the old and the new output, P_1 and P_2 for the old and the new total profit per unit of time, v_1 and v_2 for the old and the new variable unit cost, F_1 and F_2 for the old and the new (avoidable) fixed costs, e_1 and e_2 for the elasticity of demand (or more correctly for the elasticity of the average revenue curve as discounted for all repercussions and risks) at q_1 and q_2 , and finally E for the average elasticity of the same curve between q_1 and q_2 .

(Continued from p.25.)

relevant product of the firm. Firms with an elastic demand curve are, hence, more inclined to scrap their old equipment (in the same way as they are also more inclined to other output-increasing innovations) than firms with an inelastic demand curve (such as monopolistic firms).

New methods that promise net profits larger than the net profits, but smaller than the gross profits, with the old method, do not justify the immediate scrapping of the old equipment. But the emergence of such methods does accelerate this happening, since it brings nearer the time when the increase in the maintenance and variable costs due to wear and tear has reduced the gross profits earned on the old equipment below the net profits expected from the new equipment. This is so because it results in higher net profits being connected with a new equipment than would be in the absence of the new method.

The fact that there is a period during which the firm is unwilling to adopt a superior new method is, of course, a powerful temptation for buying up its patent right in order to suppress it for that time.

Then $p_1 = \frac{v_1}{1 - \frac{1}{e_1}}$ and $p_2 = \frac{v_2}{1 - \frac{1}{e_2}}$.

Hence $\frac{p_1}{p_2} = \frac{v_1}{v_2} \cdot \frac{1 - \frac{1}{e_2}}{1 - \frac{1}{e_1}}$

$$q_2 = q_1 \cdot \left(\frac{p_1}{p_2} \right)^E = q_1 \cdot \left(\frac{v_1}{v_2} \cdot \frac{1 - \frac{1}{e_2}}{1 - \frac{1}{e_1}} \right)^E$$

$$P_1 = p_1 q_1 - v_1 q_1 - F_1 = \frac{v_1 q_1}{e_1 - 1} - F_1$$

$$P_2 = \frac{v_2 q_2}{e_2 - 1} - F_2 = \frac{v_2 q_1}{e_2 - 1} \cdot \left(\frac{v_1}{v_2} \cdot \frac{1 - \frac{1}{e_2}}{1 - \frac{1}{e_1}} \right)^E - F_2$$

The surplus profits on the innovation, per unit of time, are:

$$P_2 - P_1 = F_1 - F_2 + \frac{v_2 q_1}{e_2 - 1} \cdot \left[\left(\frac{v_1}{v_2} \cdot \frac{1 - \frac{1}{e_2}}{1 - \frac{1}{e_1}} \right)^E - \frac{v_1(e_2 - 1)}{v_2(e_1 - 1)} \right]$$

If $e_1 = e_2 = E$, we obtain the simpler formula

$$P_2 - P_1 = F_1 - F_2 + \frac{v_2 q_1}{E - 1} \cdot \left[\left(\frac{v_1}{v_2} \right)^E - \frac{v_1}{v_2} \right]$$

It can be seen from this formula that in the case of output-increasing innovations (when $v_2 < v_1$) a high average elasticity of the average revenue curve is favourable for their profitability, while output-decreasing innovations (which imply $v_1 > v_2$) tend to be encouraged by a low elasticity of this curve. At the same time, if this elasticity is higher at the new output than at the current output, this fact is an additional inducement for the innovation in question.

Now the elasticity of the average revenue curve is high in the case of products that have close substitutes, which is the case with competitive firms. It may, however, tend to decrease at low prices if these substitutes cease to compete with it in this price range, thus making an output-increasing innovation all the more lucrative.

On the other hand, firms in a strong monopoly position are less inclined to adopt markedly output-increasing (price reducing) innovations, though they may be very keen to introduce innovations which decrease their costs in the range of the actual output unless they fear they will be deprived of the resulting gains by the government or by the trade unions. (Even the fear of a partial deprivation may be a strong deterrent, because the firms have to bear the whole risk alone. Professor Keirstead calls the state of affairs when the firm ceases innovating for this reason the senility of the firm.)

It must also be taken into account that there is a possibility that the total and ^{the} average revenue curves of the firm may have a kink at a certain point and that, hence, its marginal revenue curve may be discontinuous. Professor P.M. Sweezy has shown that this applies to oligopolistic

firms in relation to the point corresponding to the current price (except for the period of a high prosperity for their industry). Professor Lange has pointed out that this fact tends to deter these firms from output-increasing innovations, unless these are very much marginal-cost-reducing. (But, in the long run, there is probably a tendency for firms to grow larger also in oligopolistic industries, only firms tend to grow in jumps, i.e. rather by less frequent major innovations than by continual minor ones.)

A "potential" oligopolistic kink may occur also at a price lower than the actual one, if the product in question starts to be highly competitive with the product of another firm only at this lower price. This fact may induce a firm to stop its output-increasing policy at this point unless it is able to reduce its price still further below this critical price range.

Similarly, monopolistic firms which keep their selling price at the point where the danger of potential competition practically ceases, tend to have a kink in their revenue curve at that point (since their average revenue curve is more elastic above than below this price). * They will, hence, increase their output above, and reduce their price below, its present level only if they are able to reduce their marginal costs considerably.

Output-decreasing innovations are less important, because, according to experience, innovations tend to increase the importance of fixed costs and, hence, to pay only at

* The similarity between the position of oligopolistic firms and the one of firms threatened by potential competition has been pointed out by Mr. Triffin. He calls potential competition "oligopolistic interdependence as to entry" (p.c. pp. 117-123). This similarity implies the applicability of the kinked-curve method to this case.

higher outputs. Moreover, those innovations that decrease the output of the average plant can usually also be employed profitably for producing higher outputs by means of erecting several plants.

+ +

The firm that does make use of sales promotion methods does not face given demand conditions (i.e. given demand and revenue curves for each future date), but does face given sales conditions (i.e. a system of possible demand and revenue curves depending on its expenditure on different lines of sales promotion).

Such a firm may adopt innovations both in its production and in its sales promotion methods. (Of course, innovations in production methods affect also its sales promotion expenditure, and those in sales promotion methods affect also its output policy.)

The effects of sales promotion upon the shape of the demand curve are twofold. On the one hand, it tends to attach the old customers more strongly to a certain product of the firm, to lessen their sensitiveness to the possible price (and other) advantages of the competitors' products and, consequently, to make the demand curve for this product of the firm less elastic (consolidatory effect). On the other hand, it tends to make a reduction in the price of this product more effective in gaining new customers and, therefore, to make its demand curve more elastic (expansive effect).

In the case of the price of this product being raised or only slightly reduced by the firm, the consolidatory effect tends to be preponderant, but in the

case of a substantial price reduction the expansive effect tends to predominate. This means that the firm's sales curve (which shows the firm's sales at different prices if the optimum amount of sales promotion expenditure has been laid out at each price) tends to be less elastic at materially lower prices, than the corresponding demand curve would be in the absence of sales promotion. Consequently, the use of sales promotion tends to discourage moderate output-increasing innovations (and may even encourage output-decreasing ones), but tends to encourage highly output-increasing innovations. In effect, probably a number of greatly output-increasing innovations; which had a substantial effect upon the life of the average consumer, could not have been carried out profitably at all without sales promotion.

In the case of greatly output-increasing and price-reducing innovations, the commodity in question must be made popular with the lower-income groups, who could not afford it previously. In this case the principles similar to those valid for the introduction of new goods; a moderate sales promotion expenditure may be quite ineffective, while a higher one may be able to break the new consumers' initial resistance to a large extent. The decisive question is whether these increasing returns of sales promotion expenditure start soon enough to make the innovation remunerative.

Owing to the possibility of retaliation, oligopolistic conditions discourage expansive sales promotion nearly as much as they do price-undercutting. Thus the possibility of making use of sales promotion encourages output-increasing innovations in oligopolistic industries only in the case of

such firms that feel capable of price reductions so great or of sales promotion expenditures so high as not to be possibly matched by their competitors.

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The introduction of a new product poses, for the firm, the problem, beyond finding the optimum output, price and sales promotion expenditure, ~~XXXXXX~~ of finding the most profitable product.

For our present purposes it will suffice to analyse two special cases only, viz. in the first place, the firm's choice among products belonging to a group of close substitutes and, in the second place, the introduction of a "radically" new commodity.

As regards the former problem, we shall assume, for the sake of simplicity, that all these close substitutes differ in one physical parameter only (say, in weight only) from one another.

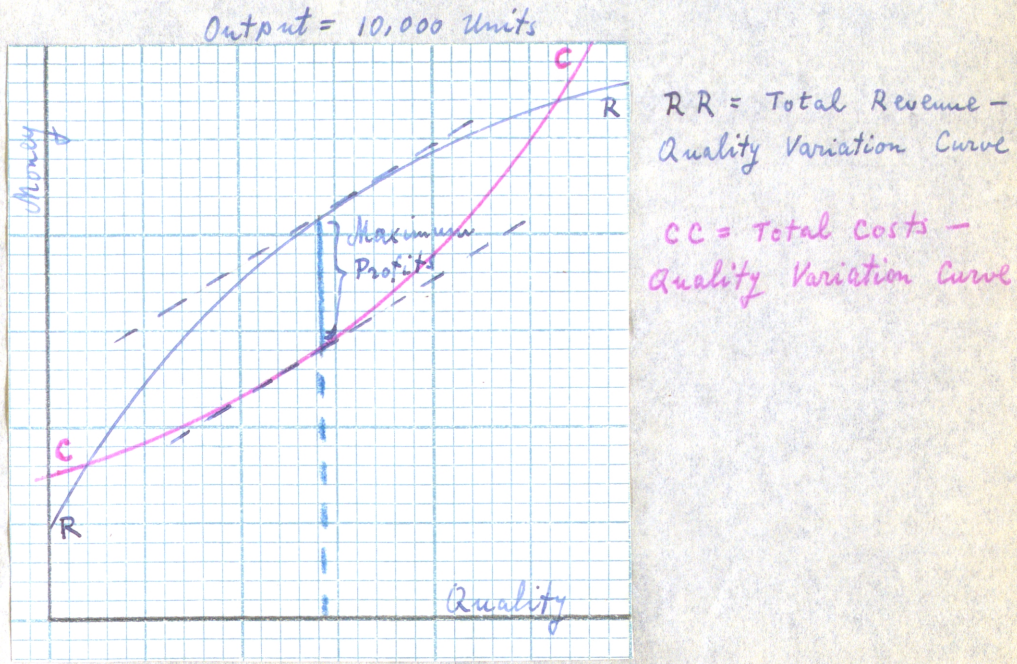


Figure 1.

Then the position may be graphically represented as follows. The relevant physical variable will be measured along the abscissa, and money along the ordinate. We shall draw two curves. The first will show how the total revenue (net of sales costs) earned by the firm on an output of a given number of units varies with changes in this physical parameter. This may be called the "total revenue-quality variation curve". The second curve will show how the total production costs of the same output vary with changes in the same physical variable. This may be called the "total costs-quality variation curve" (see Fig.1.)

For each possible size of the output, the firm will prefer that value of the physical parameter (i.e. that quality) which makes the vertical distance between these two curves - representing the total profits - maximum. This optimum quality may, of course, be different for outputs of a different size.

Finally, the different graphs corresponding to each possible size of the output can be combined into one three-dimensional model if output is represented on the third axis. Then the different total revenue-quality variation curves corresponding to different outputs will merge into one total-revenue surface, and the different total cost-quality variation curves will merge into one total-costs surface. The firm will choose that combination of output and quality at which the distance between these two surfaces along the money-dimension is the greatest, i.e. at which profits are the highest.

For our present purposes, however, it will suffice to analyse the firm's choice among different qualities on

the basis of a two-dimensional graph corresponding to a given output. ^(see Fig 1 on p. 32.) The total revenue-quality variation curve and the total costs-quality variation curve closely correspond to the familiar total-revenue and total-costs curves of the firm, the only difference being that the abscissa represents a physical parameter expressing quality, instead of representing output. But, in the same way as the extent to which it pays for a firm to expand its output, depends on the slopes of the total-revenue and of the total-costs curves, so also the extent to which it pays for it to improve quality depends on the slopes of the total revenue-quality variation curve and of the total costs-quality variation curve.

This implies, for instance, that, in the same manner as an innovation tends to result in a higher or lower output according to whether it decreases or increases marginal cost (as Professor Lange has shown), so an innovation also tends to lead to an improvement or to a deterioration in the product according to whether it decreases or increases the marginal cost of quality improvement (i.e. the slope of the total costs-quality variation curve), in other words, according to whether it reduces more the production costs of better qualities or rather those of worse qualities.

The precise extent, however, to which a given change in the cost conditions affects the quality of a product depends upon the slope of its total revenue-quality variation curve.

It is relatively easy for a competitive firm to increase its revenue by price reduction or by quality improvement, since its products compete with close substitutes from which customers can be enticed to its own products (and vice versa) with little difficulty. In the case of a monopolistic firm, however, price reduction or quality improvement tends to have a lesser effect, since its revenue can be increased only at the expense of the consumers' expenditure on distant products or at the expense of their savings. Therefore, both the total-revenue curve and the total revenue-quality variation curve tend to be steep (elastic) in the case of competitive firms, and to be flat (inelastic) in the case of monopolistic firms.

This implies that competitive firms are more inclined both to output-increasing and to quality-improving innovations than are monopolistic firms. On the other hand, monopolistic firms are more likely to reduce output or to allow quality to deteriorate.

Professor Fellner [⌘] has shown that oligopolistic conditions discourage quality competition much less than price competition. This means that the total revenue-quality variation curve of an oligopolistic firm does not show such a kink, or at any rate a kink so marked, as its total (and average) revenue curve does.

In any case, quality competition is the most keen in industries with an atomistic competition. This is not

[⌘] See his *Competition among the Few*, pp. 183-186.

an unmixed advantage, however, as Professor Chamberlin has pointed out, since it tends to prevent the full utilization of the economies of large-scale production.

+ + +

While the importance of innovations affecting existing products lies in the reduction of production costs, that of the introduction of new products is primarily in satisfying "potential" or "latent" demand. The more a product is radically new (i.e. has no close substitutes among existing products) the more is it true that its profitability depends less on its low costs of production than on the possibility of creating a sufficient demand for it without prohibitive sales costs. A radically new product cannot be really cheap or dear, because there is no standard of comparison. In the limiting case (if indivisibilities are provisionally disregarded) a given amount of preparatory sales promotion expenditure, preceding the actual marketing of the new product, will induce the consumer to spend a definite amount of money on it (or a definite fraction of his income) largely independently of its price. We may define an individual "initial demand curve" for each consumer, which expresses his initial demand for the new product. This will be a constant-outlay curve, i.e. will have approximately a unit elasticity. (See Figure 2 on p. 41). The same holds for the initial demand curve of the whole market.

As soon as the initial selling price has been published, however, the "initial" demand curve gives place to a "permanent" demand curve, which expresses the

consumers' response to price alterations, instead of to the initial price as the "initial" demand curve does. This will intersect the initial demand curve at the initial price, but will be more elastic than this initial demand curve, since the publication of the initial price results in providing a standard of comparison for the consumers. (See Figure 6 on p. 42.) They will resent price rises, while price reduction will have the effect of an additional inducement for them. (Later, when consumers have become used to the new product, the demand curve may again become less elastic.)

The position of the initial demand curve (the amount of money that consumers are ready to spend on the new commodity corresponding to a given preparatory sales promotion expenditure) depends on the standard of living, on the distribution of income, on the general attitude of the community towards novelties, on the relation of the new commodity to the prevalent cultural values etc. - in brief on how intensive a latent demand there is in the community for the new product in question. It depends, of course, also upon the efficiency of existing sales promotion techniques.

It has been pointed out that in the case of new products an initial resistance has to be overcome on the part of the consumers, in which small sales promotion expenditures tend to be quite ineffective, but larger expenditures tend to have quickly increasing returns. The problem is whether these increasing returns start below prohibitive sales costs or not. The maximum amount of sales costs which can be expended depends, of course, on the size of profits expected later and on how long these

profits are likely to be maintained against the probable emergence of cheaper or better competitive goods.

We have now to consider the influence of indivisibilities upon the shape of the initial demand curve. Commodities are never completely divisible. Even if they are so from the standpoint of the market, they are never so from the standpoint of the consumer. Below a certain quantity they cease to yield any satisfaction (case 1). Moreover, in many cases only multiples of a certain indivisible unit can be consumed (case 2). Under other conditions each consumer is likely to buy no more than one unit of the commodity for a certain period (case 3). (See Figures 3, 4 & 5, on p. 41.)

The amount of money that a given consumer would be ready to spend on the new commodity in response to a given amount of preparatory sales promotion expenditure depends considerably on his income. If the price of the new commodity is so high as to prevent his buying at least the "minimum quantity" of it for this amount of money, he will rather withdraw completely from the market. Hence the first two cases of indivisibilities tend to make the initial demand curve highly elastic at low prices (unless the indivisible minimum amount of the commodity is very small), because a slightly higher initial price would exclude a large number of less wealthy consumers from the market. At the same time, at higher prices this initial demand curve is still likely to have an elasticity not much above unity. In the third case, on the other hand, the fact that the consumer is unlikely to buy at one time more than one unit of the commodity, however low its price, tends to make the whole curve less elastic than it is in the first two cases.

All in all the initial demand curve of radically new products is likely to have an elasticity not much above unity at higher prices and to be greatly or even extremely elastic at low prices. (But at very low prices they may become inelastic again, viz. at the price at which practically every consumer is able to buy the "minimum quantity" of the new commodity.) This means that a firm that introduces a radically new product may profitably insist on a very high profit margin per unit of product, if its production and/or sales costs are high, but may profit from contenting itself with a low-percentage profit margin if the product can be produced and sold at low costs. The latter case, of course, is ^{also} a strong temptation for resorting to a price discrimination if practicable (i.e. for charging wealthy consumers a considerably higher price, by marketing, for instance, a special luxury brand of the commodity).

We have seen that the total-revenue curves and the total revenue-quality variation curves of monopolistic firms tend to be rather flat, i.e. that cost reductions and quality improvements tend to have a relatively small effect upon their sales. In the case of s u b s t a n t i a l cost reductions or quality improvements, however, this effect may nevertheless be quite considerable and such innovations may be fairly lucrative even for monopolistic firms. Similarly, the introduction of new commodities, which can be regarded as an extreme case of quality improvements, tends to be worth while for monopolistic firms as well.

Let us consider, for instance, the case of an artificial-silk manufacturer in a monopolistic position. A small cost reduction or a small improvement in his

products may be rather ineffective in raising his sales, for it does not induce consumers to reduce their consumption of distant commodities or to decrease their savings. But an innovation like the introduction of nylon may expand his market quite considerably, since it may make him successful in competing also with cotton and wool products, or even with radios and washing machines.

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Our results have obvious implications for the use value of inventions.

The use value of cost-reducing inventions tends to be higher for large firms than for small ones, since the former are usually able to apply such an invention to a greater output. The use value both of cost-reducing and of quality improving inventions tends to be higher, other things being equal, for competitive than for monopolistic firms. In the case of g r e a t l y cost-reducing or g r e a t l y quality-improving inventions, however, this difference may be less marked, since the profitability of these tends to depend less on intra-industry, than on inter-industry competition. As for oligopolistic firms, we have seen in what manner they occupy a position intermediate between monopolistic and competitive firms.

The Initial Demand Curve of an Individual Consumer.

In the Absence of
Indivisibilities.

If the Consumer Never Buys
Less than a Minimum Amount (Case 1.)

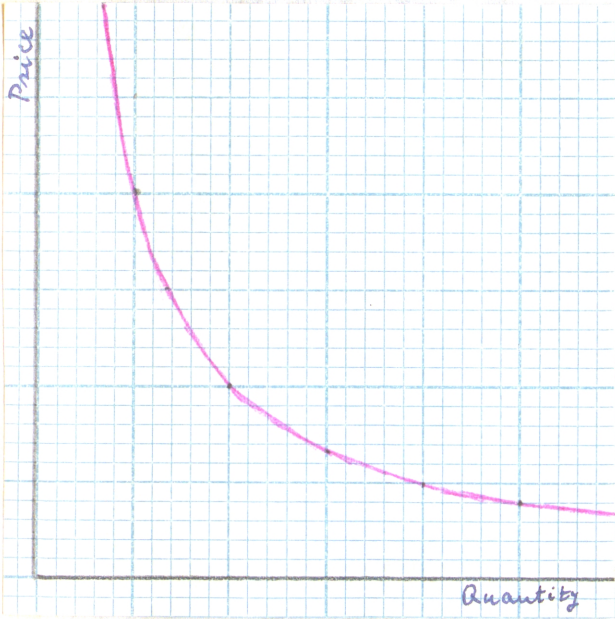


Figure 2



Figure 3

If the Consumer Buys Only
Multiples of a Certain Unit
(Case 2)

If the Consumer Buys at Most
One Unit (Case 3.)

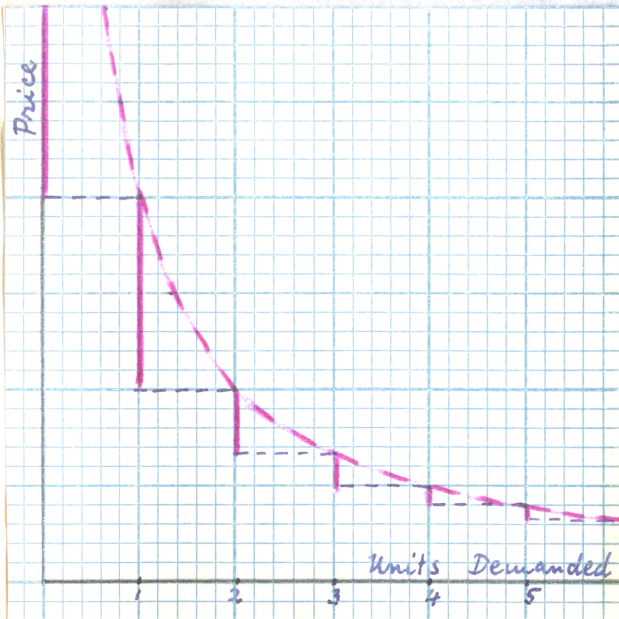


Figure 4.

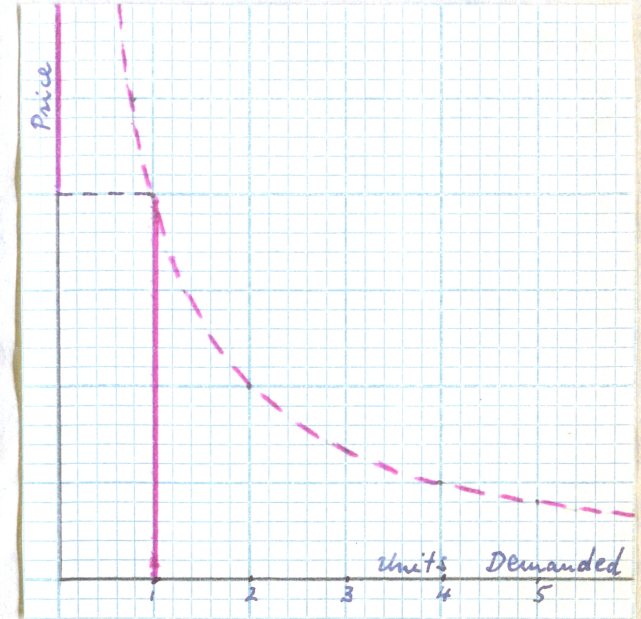


Figure 5.

The Initial and the Permanent Demand Curve
of the Market.

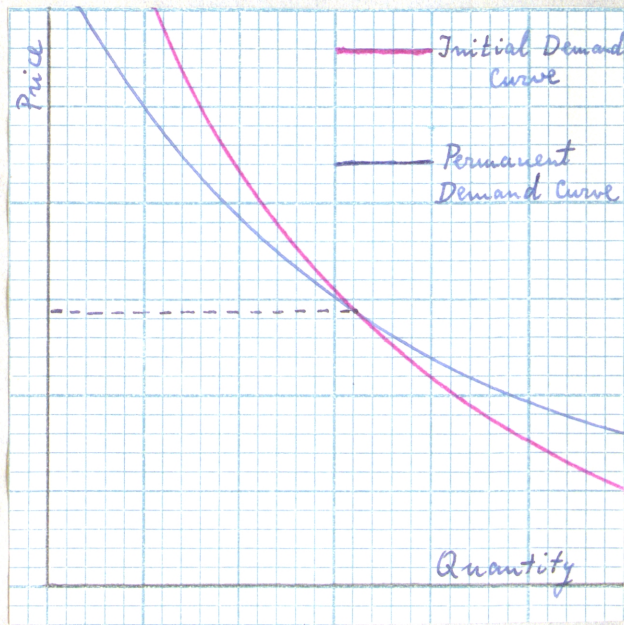


Figure 6.

IV. The Research Expenditure of the Firm.

According to experience, firms usually undertake the development of inventions only for their own use, and do not produce inventions for the market. * They tend to be interested only in devices that reduce the production costs, or improve the quality, of their actual products, or that result in new products which can be produced or marketed to a special advantage, together with their actual products, and with the help of their actual personnel and equipment,

It sometimes happens, to be sure, that a firm works out inventions intended for use by other firms, mostly by firms in other industries, because it wants to create new uses for its products, or wants to improve the quality or to reduce the costs of the raw materials, and of the equipment, it has to buy. But these inventions are also not being developed in order to make a profit on selling them.

Similarly, there are consultant laboratories that regard it as their main business to develop inventions for other firms, but they do this only to the latter's explicit order and do not produce inventions simply for the market. The initiative comes, also in this case, from firms that directly need these inventions.

* Of course, the small independent inventor has produced inventions for sale. This has not proven to be very profitable, however, since he has often had to sell his inventions far below their real use value. He has fared usually much better if he was able to raise the capital required and to exploit, himself, his inventions. (Naturally, in this case he has had to bear also greater risks.)

The reason for this fact apparently lies in the imperfections of the market for inventions. The selling price for inventions (for patent rights or for industrial secrets) tends to be considerably less than their use value is for the purchasing entrepreneur. This is due to a number of factors: to the small number of possible buyers; to the difficulty of estimating correctly the risks connected with the adoption of an invention; to the imperfect knowledge both of the buyer and of the seller, both of whom probably tend to under-estimate the use value of this commodity, the buyer for lack of technical training, the seller for lack of information about the buyer's business opportunities. Moreover, outsiders often do not know even what kinds of improvements are really needed, or needed most, by a particular firm or industry and are, hence, unable to direct their research to the most profitable channels, which likewise discourages the production of inventions for the market.

Actually, business firms, including those that are very active in research, undertake to develop no more than a fraction of those inventions that are connected with their actual or potential products.

Of course, an efficient firm would hardly fail to develop any useful device that entails only moderate development costs (except, indeed, if its practical adoption required too expensive changes in the firm's equipment or personnel). Many new cost-reducing or quality-improving devices are only a routine application of recent inventions of other industries, or of long-known principles that could not previously be applied with profit in this particular field. There is, for instance, always a large number of industrial operations that could have been mechanized for a long time, and for which the

machines required will be developed without delay as soon as the need arises to perform these operations on a larger scale. New inventions of this sort do not usually require extensive research work. They may actually involve nothing more than a routine engineering problem. Moreover, many minor inventions result without significant research costs from an attempt to remedy complaints against the quality of the firm's products, or to eliminate troubles in the production process.

The firm, however, undertakes only a fraction of the possible research projects that, being based upon really new principles, promise great improvements in its products and production methods, but only at the price of substantial research expenditures. First of all, a good many of the possible major inventions that could greatly reduce the firm's production costs fall completely outside the field of the firm's research activities, because they require skills, experience and equipment more readily found in another industry. (Inventions that improve quality or that result in new products are less likely to fall outside the firm's special research territory.) For instance, hardly any chemical firm would attempt to reduce its costs by developing a new type of electro-motor, even if it had to use electro-motors on a considerable scale. A chemical firm would probably undertake research in this field only if a new type of electro-motor were absolutely essential for one of its operations. In any other case the development of a motor of a new type would be left to the electro-motor industry, which could do it at much lower costs and could make a much more extensive use of the invention thus developed.

In this respect there are considerable differences among various industries. Some industries find their production methods largely determined by their equipment bought

from other industries. Often these do not do anything to reduce their production costs besides watching the new developments in the industries that produce their equipment and making the best use of these novelties. Their own research work they tend to concentrate rather upon developing new product qualities and completely new products. This is, for example, the case with the toy-making industry. Other industries; on the contrary, have a considerable scope for original cost-reducing improvements in their production methods. This applies, for instance, to a part of the chemical industry. [⌘]

On the other hand, the number of the large-scale research projects undertaken by a firm is confined by the fact that it has a use only for a limited number of major inventions in any given period of time. It cannot make radical changes in its production methods and products too frequently, since the fixed costs of introducing a given production method or product must on the average be recovered before it is given up for another. In the case of new production methods these fixed costs include the costs of the new equipment required and the losses in production during the re-conversion period. In the case of new products there are, in addition, the heavy initial advertising costs and the losses due to the initial low volume of sales.

[⌘] Even in the case of industries of the latter type, however, a greater part of a firm's large-scale research projects often aims at developing new qualities and new products, rather than at cost-reducing inventions, since the number of possible new qualities and new products tends to be considerably higher than the number of the possible new production methods for the firm's actual products.

Moreover, a firm is not only unable to replace its old products by new ones too frequently, but it is also unable to increase the number of its concurrent products by the addition of new ones indefinitely, since the size of the firm is limited by the decreasing efficiency of the management, the increasing risks, and the increasing difficulty of raising additional capital, connected with a growth of the firm beyond a certain point.

The number of the major inventions a firm can use in a given period of time is determined by the number of its products and by the average time for which each production method and product is kept in operation. This average time of operation is determined by a compromise between two conflicting considerations. On the one hand, the firm tends to make higher profits on new methods of production and on new products (except for the very initial period of their introduction) than on old ones, which have usually been caught up or surpassed by the competitors. This encourages the shortening of the average time of operation of each method and product. On the other hand, a shortening of this time tends to result in an increase of the fixed costs of the firm, as already pointed out, which fact works in the opposite way.

Owing to the former consideration, this average time of operation is unlikely to be much longer than the physical depreciation period of the major parts of the firm's equipment, since it is worth while each time to connect the replacement of equipment with an innovation at least in the methods of productions and possibly also in the product produced. On the other hand, owing to the latter consideration, this average time of operation cannot be much shorter, either, than these physical depreciation periods.

The Profit Curve of an Innovation.

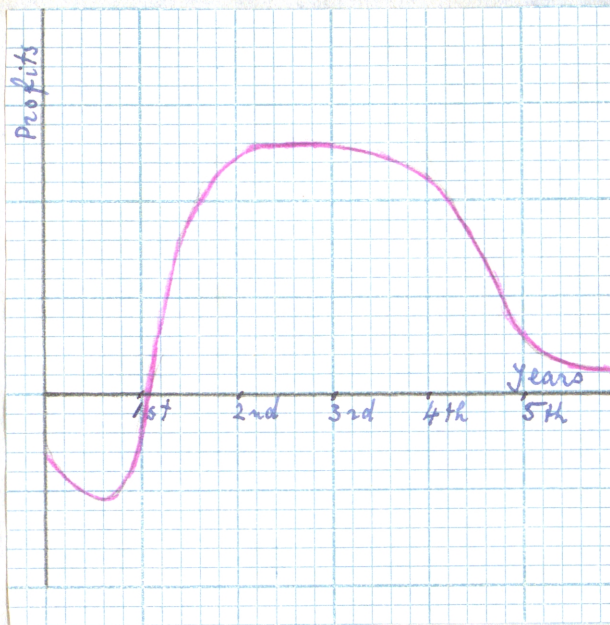


Figure 7.

Let us define the firm's profits within a given period of time so that they are equal to the excess of the firm's receipts collected in that period over its expenses paid out in that same period. Then the firm's profits on a given product with a given production method are likely to be very low, possibly even negative, in the initial period when the fixed costs are incurred (see Fig.7). They tend, however, to rise steeply afterwards and to remain nearly constant at a high level for some time, and then to drop again, first slowly, and later rather suddenly. At last they may become stable once more, but at a rather low level. The firm is, however, likely to give up the product in question, or to change its production method, long before these profits have fallen to their lowest level.

More exactly, the firm tends to replace this product or this production method at that point at which the profits on it have fallen below the level of the profits expected from the new product or production method, as taken, on the average, over its whole future time of operation. (This "average" is calculated by counting the profits of each future year at their discounted present value. Therefore, this "average" means the amount of the constant annuity enjoyed over the same period of which annuity the present value is equal to the present value of the expected profits.) The firm may be imagined to draw both the profit curve for its present product or method and the one for the new product or method, and then to average the latter. The old product or method will be replaced by the new at the point at which the average-level line of the latter curve intersects the former curve (see Fig. 8).

The Determination of the Date when
the Next Innovation Should Be Started.

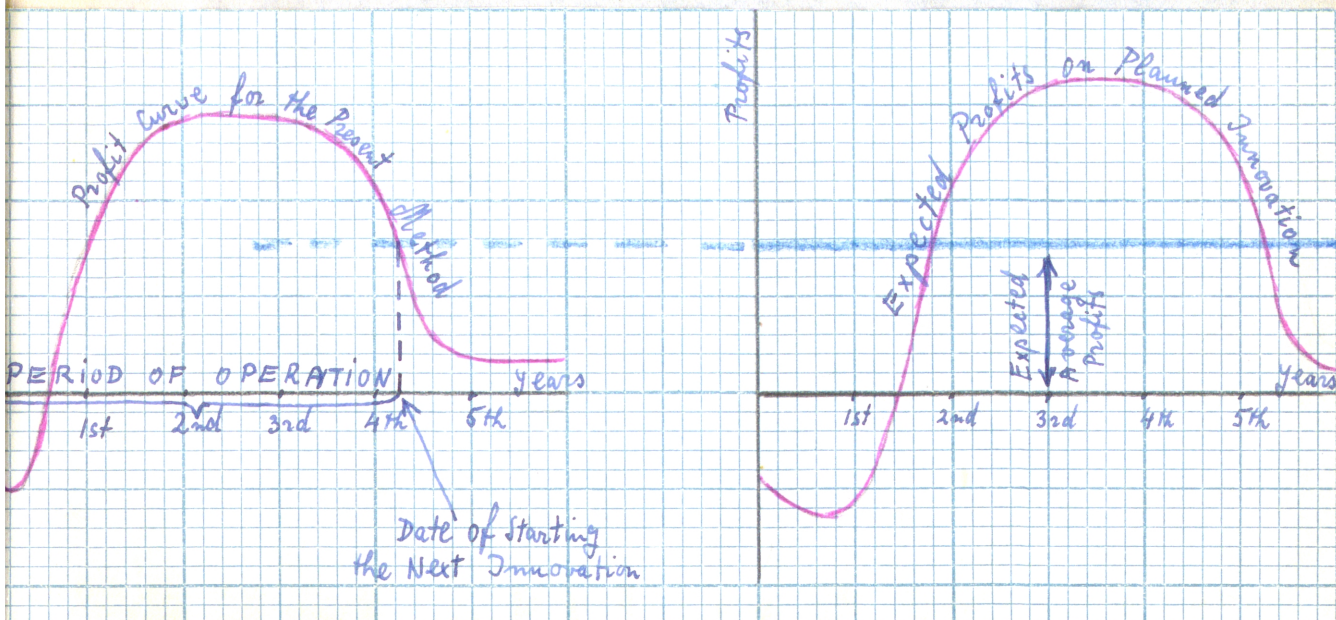


Figure 8.

Knowing the number of its products and the average period of operation of a major invention, the firm can calculate the number of major research projects it should undertake. Of course, it has to take into account the fact that the completion of a major research project often requires considerable time, for which reason an adequate supply of new inventions can be secured only by a careful timing of the research projects. Moreover, some of the research projects may prove a failure, or may be completed later than originally expected. Therefore, the firm must start a somewhat larger number of projects in order to have a safety margin. * In the case of very long-term projects, on the other hand, the firm has to make allowance for the fact that at the time of their completion it may have reached a larger size, may produce a higher number of products, and may need a larger supply of major new inventions, than at present.

The selection of the research projects for development is often influenced by the competitors' research activities (as far as there is information available on them). The very fact that a competitor has undertaken research in a certain line may induce the firm to follow suit. However, if the development of a certain new invention is very expensive, while it may be hoped that the new invention will be easy to copy once it has been brought out by the competitor, it may be preferable, on the contrary, to stop any research-work in the line in which the competitor is known to be working. Even if the competitor's original device cannot be taken over without change because of

* In general, the risks entailed by research tend to discourage research expenditure. But in this connection these risks tend rather to increase it.

the patent law, it may still be much cheaper to evade the patent law by developing an alternative invention based on roughly the same principles than to develop the invention independently. (Smaller firms may be even tempted to restrict themselves completely to imitating their larger competitors.)

Moreover, in a number of fields there is such an abundance of possible new products (or of new product qualities) that it may be advisable as a general policy for a firm to leave the lines attacked by its competitors alone, and to concentrate rather upon untrodden paths, where it may hope to establish a kind of monopoly position. Such an inter-firm specialization in research tends, of course, to result eventually in a specialization in production (product differentiation) as well.

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The total research expenditure of the firm depends both on the number of the research projects undertaken and on the sum spent upon each project.

We have dealt with the former factor already. We have seen that there are practically no external limits to the number of minor research projects undertaken. It is advisable for the firm to attempt to solve practically all the minor technical problems arising in connection with its productive activities and to omit none of them. We have found, on the other hand, that out of the possible major research projects a firm tends to choose only a fraction for development, their number being determined by the number of major inventions needed by it in each period of time.

Similarly, the firm's expenditure on the single minor research projects does not need any special analysis. Each minor project tends to be allotted the amount of research costs needed as determined by technical factors. At the same time, the total amount spent in each year upon routine research work on minor projects tends to show some degree of constancy as a percentage of the value of the firm's total output, in accordance with the laws of probability, in the same way as, say, the maintenance costs of equipment tend to show some extent of stability owing to the same laws. Even among different firms, or among different industries, some degree of uniformity may be expected similar to the one found in maintenance costs, for instance.

A real economic problem is connected only with a firm's expenditure on its major research projects. In this connection a firm has usually a choice as to whether it tries to work out more ambitious inventions at higher development costs or, rather, less ambitious ones at lower development costs. The firm's actual choice will depend on its size and on the degree to which it is in close competition with other firms.

We have seen (p.25) that larger firms tend to have a higher use value for a cost-reducing invention, since they can usually apply it to a greater output. This implies that they are more likely to find it worth while to expend large sums upon a major cost-reducing invention. They may also find the capital required more easily.

We may now add that a larger firm can usually better utilize an invention resulting in a new quality or in a quite new commodity as well, because they have more capital for fully exploiting the possible market for a new quality or a new commodity.

These considerations are offset, to some extent, by the fact that many large firms are more or less in a monopolistic position and have, therefore, rather inelastic revenue curves and total revenue-quality variation curves (see p. 35). This fact is especially important for the case of quality-improving inventions. It tends to limit the expenditure of the firm upon quality-improving research. For instance, in the case of the example considered on pp. 39-40, if a firm can choose between developing nylon and between developing an even better material at considerably higher development costs, * its choice may greatly depend on whether it has to reckon with competitors who, also, will come out with new materials of this sort within the next few years. In the absence of such competition the firm is more likely to content itself with attacking the less expensive research project, since, in this case, beyond a certain point a further improvement in the material produced by the firm ceases to increase its market noticeably. (A monopolistic firm would, in addition, take into account also the fact that an improvement in the quality of its products, if this implies a higher durability, would decrease the consumers' replacement demand.)

Monopolistic behaviour like this may possibly result simply from the fact that an inter-firm specialization comes to be developed in an industry in the way indicated above (see p. 51). For instance, the firm of our previous example may owe its monopoly position in the field of silk substitutes to the fact that its competitors have specialized in other sorts of synthetics, say, in wool substitutes, in synthetic rubber, in plastics etc., while giving up research in artificial silk.

* We assume that the production costs of both materials, once being developed, would be about the same.

Whereas monopolistic (i.e. inelastic) total revenue-quality variation curves (and, to some extent, also inelastic revenue curves) are an important factor in the theory of the firm's research expenditure, oligopolistic interdependence (kinked curves) plays a less important part. As Professor Fellner has shown, it is unlikely that a firm in an oligopolistic industry would refrain from increasing its research expenditure because of the mere fear of retaliation on the part of its rivals. This is so because the effects of a competitive increase in its rivals' research expenditure are much too uncertain to be very formidable, and the firm may well be confident that it will be more successful than its rivals. Moreover, competition in research is less dangerous since it can hardly become a cumulative process as, say, price competition may do. *

Besides the shapes of the firm's short-run revenue curves and total revenue-quality variation curves (which determine the size of the firm's initial profits on the introduction of a certain invention), a very important factor is the time for which the firm is likely to be able to maintain these profits against competition. In cases when a new invention is unlikely to be caught up by competitors for a considerable time, it may more readily justify the undertaking of large research costs for its development.

On the other hand, the probability that the profits on a new invention may have to be shared with the trade unions or with the government, may have a seriously deterring effect. (We have seen on pp. 21-23 that a possible method for allowing for these factors is to deduct the losses expected on these accounts from the firm's revenue, in which case they come to be expressed in a decreased elasticity of the firm's relevant curves.)

* See Fellner, *Competition among the Few*, pp. 183-185.

So far we have considered factors influencing the use value of inventions for a firm. The firm's research expenditure, however, also depends, of course, upon the technical possibilities open for research in the firm's special field at the time.

Two general rules apply in this connection. In the first place, a firm would not undertake a research expenditure upon a research project larger than the use value of the invention expected to result from it, these research costs being calculated with a due allowance for the risks involved (cf. pp. 12-13). In the second place, a firm gives preference to a more expensive research project over a less expensive one if, ^{and only if,} the difference in the development costs is more than offset by the difference in the use value of the inventions expected to result from the two projects.

The first rule implies that in fields in which no very important invention seems to be possible, the research expenditure per project of each firm must be low. The second rule means that high research expenditures tend to be worth while especially in those fields in which the solution of a very important technical problem seems to be possible by a higher expenditure but to be impossible by a lower one, i.e. in which an increase in research expenditure seems to have very high returns on the margin.

The Return Curve of Research Expenditure.

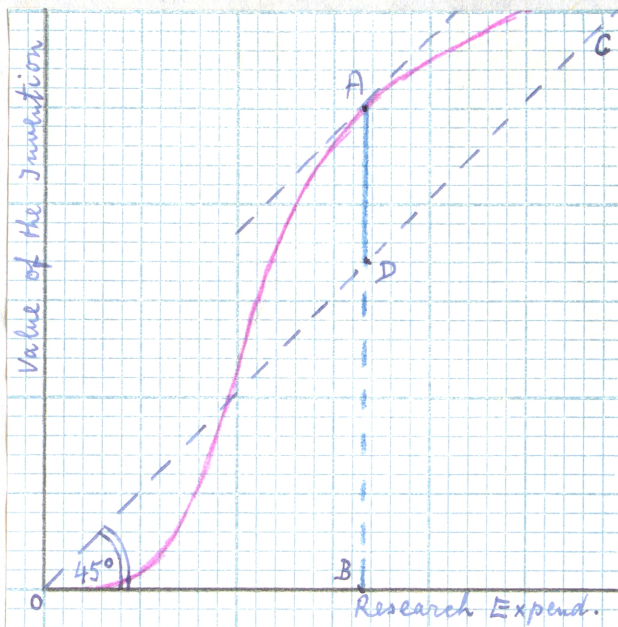


Figure 9.

Figure 9 gives a graphical representation of this Chapter's argument. It shows the use value of the best invention that can be developed by expending a given amount of development costs as a function of these development costs. The curve representing this function may be called the return curve of research expenditure. For instance, at development costs OB an invention of use value AB can be developed. The line OC is drawn at an angle of 45° , hence $BD = OB$ and $AD = AB - OB$ represents the firm's net gain on the research project. The first rule above means that research is undertaken only if this net gain is positive, i.e. only such research expenditures will be chosen at which

the curve rises above the line OC. The second rule expresses the fact that the firm will try to maximize its net gain. This net gain has, however, a maximum at the point (or points) at which the slope of the curve is 45° , provided that the curve is concave (as seen from below) at that point. This is so because up to such a point a given ΔR increment in research expenditure results in an increment in the use value of the emerging invention larger than ΔR , while beyond this point the opposite is true.

$AD > A'D'$

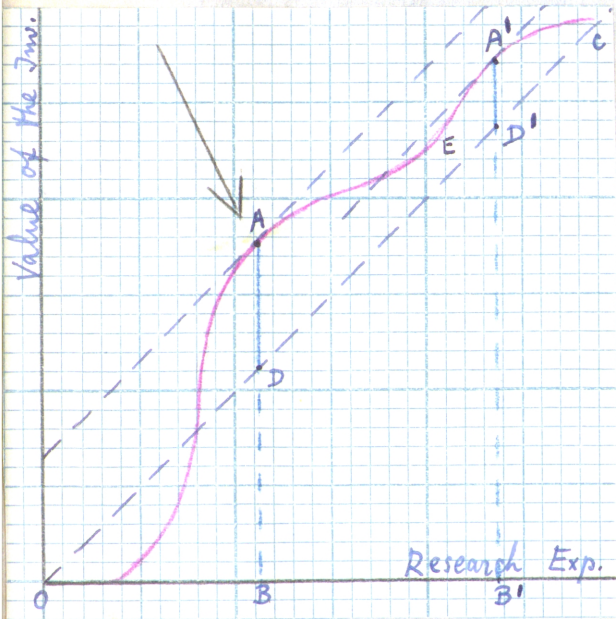


Figure 10.

$AD < A'D'$

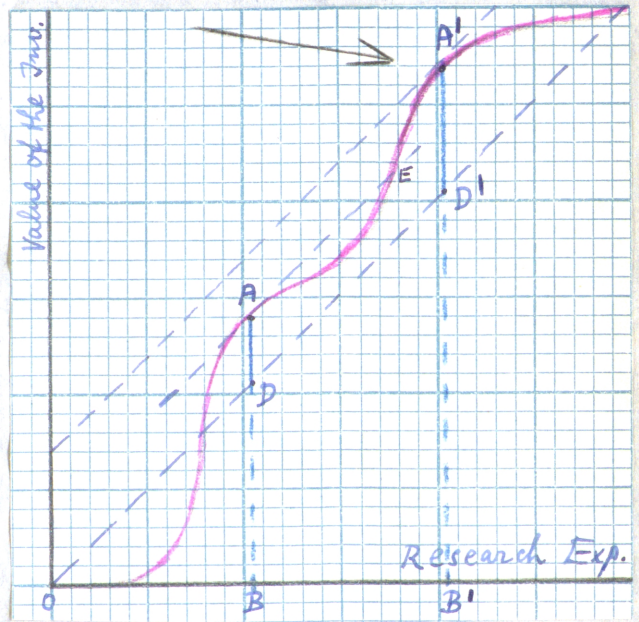


Figure 11.

The return curve of research expenditure may have several such points at which the firm's net gain on the research project has a local maximum (see Figures 10 and 11). Out of these points that one will be chosen which represents the highest net gain of all. i.e. which lies highest above OC.

For instance, in the case represented by Fig.10 the maximum corresponding to a lower expenditure will be chosen (since $AD > A'D'$), while in the case represented by Fig.11 the opposite applies (since $AD < A'D'$). On each Figure the range EA' , in which the curve takes a steep upwards turn (i.e. shows increasing marginal returns), expresses the fact that in this range a relatively small increase in the research expenditure makes possible the solution of an important technical problem which could not be solved at somewhat lower costs. But in the case of Fig.10 these increasing returns are not significant enough to make their exploitation worth while. Though an increase in research expenditure may make the solution of a fairly important problem possible, this increase will still not be granted, since the additional costs are not justified by the importance of the problem. the opposite is true in the case of Fig.11.

Since the return curve of research expenditure shows the use value of different inventions for the firm, its shape may be very different for firms working even in the same technical field, as these use values depend considerably on the size of each firm and on the degree to which it has a monopoly position. Other things being equal, this curve tends to rise more steeply over its whole course in the case of large firms on the one hand, and in the case of competitive firms on the other hand. Moreover, the slope of the curve tends to be steeper the longer the time for which the firm can hope to be able to maintain the higher profits resulting from the introduction of a new invention. At the same time, any influence that raises the slope of the curve tends to increase the firm's expenditure on each of its research projects and vice versa (cf.pp.52-54).

We have seen that the productivity of research work in a given field tends to exhibit considerable fluctuations over a period of time (see pp. 15-17). These fluctuations obviously show themselves in the shape of the return curve for research expenditure. An increased productivity of research, for example, due, say, to a fruitful new discovery, tends to raise the curve and to encourage, hence, higher research expenditures. This need not be so, however. The effect of a higher productivity upon the shape of the curve may be such that the curve rises to a high level already at low expenditures, but fails to rise much higher even at high expenditures (see Fig. 12). This will be the case if even low research expenditures promise valuable inventions in a given field, but if higher expenditures cannot produce much better inventions than these, either. Such a position would, of course, discourage high expenditures.

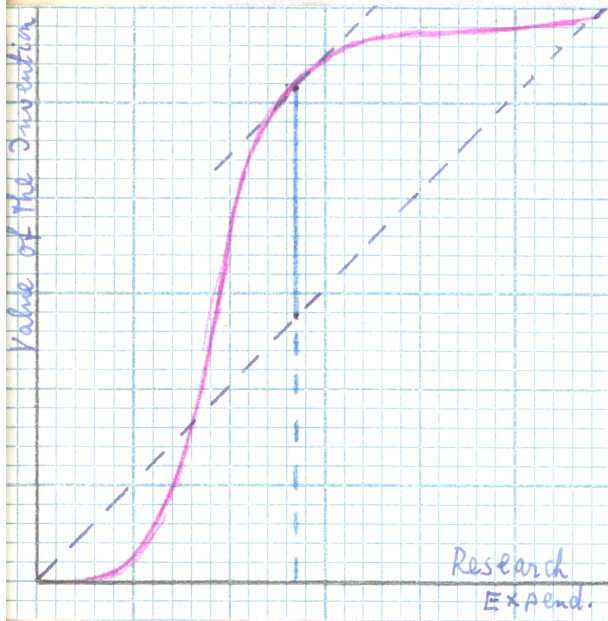


Figure 12.

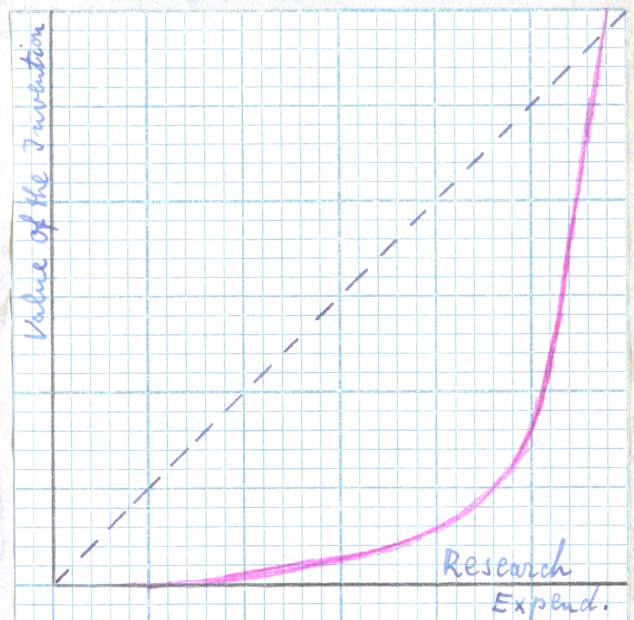


Figure 13.

On the other hand, the opposite case is also possible. A low productivity of moderate research expenditure may well be compatible with a high productivity of large research expenditures in a given field, i.e. the return curve of research expenditure may remain rather flat over a long initial range, but later may still rise steeply to a considerable height (see Fig.13). This may be due to the fact that significant results in the field concerned are only possible after the solution of a certain central technical difficulty very expensive, but still worth while, to solve.

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According to empirical data, the research expenditures of firms in the same industry and even of those in different industries show a remarkable uniformity, at least in the case of firms active in research. This expenditure amounts to about 3% of the value of a firm's total output, or at least tends to lie between 2 and 4% of this sum. [ⓧ] (Small firms tend to spend a somewhat higher percentage.) We have already pointed out that it is to be expected that the expenditures of firms upon minor research projects of a routine nature should exhibit some degree of uniformity (see p. 52). A firm's expenditure upon major research projects, on the other hand, has been found to depend upon the number of such projects undertaken and upon the sum spent on each. Of these two figures the former may be expected to have a tendency to be roughly proportional to the size of the firm, since it is governed by the firm's demand for major inventions (see p. 50). There is, however,

[ⓧ] Cf. C.C. Furnas, o.c. pp. 150-151 and 406-407.

no economic reason to expect any uniformity in the amount spent on each major research project. Consequently, there is no reason to expect any marked uniformity in the total research expenditure of business firms, either.

The empirical uniformity actually found requires a different explanation. It is much more likely to be a purely conventional phenomenon than to be one resulting from economic calculations. The very scanty information we have about the principles directing firms' research-expenditure policy seems to indicate that at present most firms have no economic criteria at all for deciding the size of these expenditures, but rather that they rely to a large extent upon more rules of thumb, or more exactly, that they simply imitate the policy of other firms and follow percentages developed in the industry owing to historical accidents. They spend 3% on research simply because this is the practice of firms recognized as efficient. Even ex post facto no reliable accounting procedure seems to be available to find out whether the funds allocated to research in the past were excessive or rather insufficient. [¶] The difficulty comes, of course, from the fact that the economic use value of an invention for the firm is very hard to estimate ex ante, and even ex post, since the market price of inventions is by no means a reliable guide. It is quite possible that, when once in the future better estimating methods are available, it will be found that the actual research expenditure of most firms

[¶] Cf. C.C. Furnas, o.c. Chap. XXI. "Evaluating the Results of Research", pp. 406-407, where a surprisingly primitive accounting method is suggested as the latest and best. (1948).

(Continued on next page.)

falls considerably short of (or, what is less likely, that it exceeds considerably) the most profitable amount even from the standpoint of the mere private interest of the firm.

(Continued from p.61.)

Mr.D.B.Hertz describes in his The Theory and Practice of Industrial Research, Chap.on "Research Economics and Budgeting", pp.209-228, a more satisfactory accounting method for research (1950), but it is questionable whether most firms actually possess the information needed for using this method in practice.

V. The Effect of Economic Demand
upon Inventing.

It has, of course, been known for a considerable time that an intensive economic demand for the solution of a particular technical problem tends to call forth the emergence of appropriate inventions. The systematic discussion, however, of the effect of demand upon inventing has been started by Professor Hicks in his *The Theory of Wages* (1932, pp. 112-135). He has made a distinction between induced inventions, which emerge in response to changes in the price situation (especially in response to changes in factor prices) and between autonomous inventions, which appear independently of such changes.

This distinction, however, seems to over-stress the importance of price changes as such. Most induced inventions are not really an adjustment to a price change, but rather an adjustment to the new price situation resulting from such a change. Their economic usefulness would not be less if the relevant price situation had not been due to a recent change in prices, but rather if it had existed at all times. For instance, the invention of certain types of oil-heated boilers was obviously induced by an increase in the price of English coal between the two wars. But it has been an adjustment to the high price of coal (as compared with the price of oil), rather than an adjustment to the very increase in the price of coal. Its usefulness depended by no means on the fact that not long before that time the price of coal was substantially lower. In effect, had the price of coal always been as high as that, these inventions would probably have appeared much sooner.

On the other hand, the same price change has induced the invention of cheaper methods for converting boilers originally built for coal-heating into oil-heated boilers. This invention was really induced by the very change in the price of coal. If this price had always been high, coal-heated boilers would probably never have become so common and the need for their being converted into oil-heated boilers would not have arisen at all.

But inventions like this, which really serve to make the transition necessitated by price changes easier, are rather infrequent and of lesser importance. Most induced inventions are actually a response to a new price situation, rather than to the change itself leading to this situation.

At the same time, a given price situation obviously tends to induce the emergence of adaptive inventions not only if this price situation is of recent origin, but also if it has been in existence for a considerable time. For instance, as Mr. Bloom has rightly pointed out, labour-saving inventions may be induced by a "continuous high price of labour" no less than by a rise in the price of labour. [⌘]

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[⌘] See G.F. Bloom, "A Note on Hicks's Theory on Invention", Amer. Econ. Rev., 1946, p. 86. We shall, however see presently that a low rate of interest is a factor more important than high wages, see p. 69 .

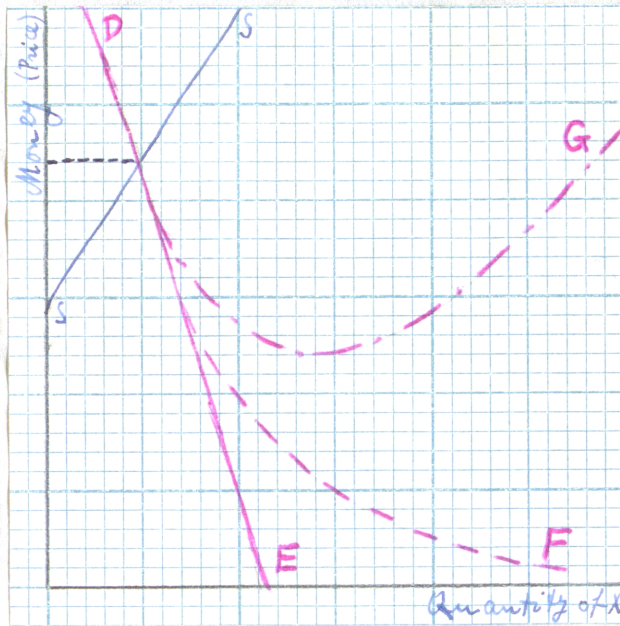


Figure 14.

The economic demand for a certain invention, however, depends not only upon the current prices, but rather also upon the whole course of the relevant demand curves (see Fig. 14). Assuming the supply curve SS for the commodity X as given, its current price is independent of whether its demand curve is DE or DF . But obviously a demand curve like DF (implying a large potential demand for X at lower prices) stimulates the invention of methods for producing X at lower costs much more than a demand curve like DE (implying no such large potential demand) does. Consequently, the emergence of

new potential uses for X (conditional upon a lower price of X) may induce the emergence of an invention like this even if this new potential demand has no effect upon the current price of X.

Moreover, the existence of increasing returns on scale may result in an upward sloping demand curve (like DG) for X, i.e. it may induce the buyers of this commodity to offer higher prices for X provided that they can obtain a larger quantity of it. This may easily be the case, for instance, with important raw materials needed in relatively small quantities (if their supply falls short even of this small demand). A bottle-neck situation like this is a powerful stimulus for the invention of methods for increasing the production of the raw material in question (or of its close substitutes).

Furthermore, inventing may be stimulated not only by the position of the "manifest" demand curve, but also by the existence (or emergence) of an extensive "latent" demand that can be made "manifest" by sales promotion. For instance, the spread of motor-cars has induced the invention of built-in radios in motor-cars. It is not as if the spread of cars had resulted in an actual manifest demand for such radios, rather it resulted in the sole possibility of arousing such a demand by advertisement. But this possibility, i.e. this latent demand, has sufficed for inducing the invention of such radios.

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The influence of economic demand upon the emergence of new inventions follows the familiar pattern of the

Marshallian Principle of Substitution.[Ⓜ] Induced inventions tend to substitute less expensive factors (and commodities) for more expensive ones.

This substitution may be an "absolute" one in the sense that an invention may decrease the demand for one factor and increase it for another, in that it reduces the marginal productivity of the first and raises the marginal productivity of the second. (Such an invention would, of course, tend actually to decrease the absolute share of the first factor in the national income, while increasing the absolute share of the second.)

But it is now usual to speak of substitution also in a "relative" sense, even if an invention tends to economize the use of both factors per unit of product. In this case it is considered as "saving" only that factor which it economizes to a higher extent, i.e. that one of which the marginal productivity it raises in a smaller ratio. (Such an invention may or may not decrease this factor's absolute share in the national income, but it necessarily decreases its relative share as compared with the share of the other factor/s/.) On the other hand, if an invention increases the marginal productivity of both factors in the same ratio, it is called "neutral".^{ⓂⓂ} (A neutral invention tends to increase the share of all the factors in the national income at the same rate.)

These definitions raise no difficulty if none of the factors between (or among) which substitution occurs is capital. In the case of capital, however, there is the difficulty that capital has to be measured in value units, not in physical units as other factors are measured. Thus, in the case of capital, it is not its price which depends

[Ⓜ] Marshall, Principles, 8th Ed., p.341.

^{ⓂⓂ} Hicks, l.c.

upon the value units used (its price is an absolute number, i.e. percentage), but it is its quantity⁺ which depends on the nature of the value units adopted. Thus the net marginal product of capital cannot be unambiguously identified and distinguished from the depreciation allowances entering into its gross product. What we regard as the net marginal product of capital depends on whether capital is measured in current money units, in commodity units or in wage (factor-price) units, and, in the last two cases, also upon the conventions adopted as to index numbers.

For these reasons Mr. Harrod and Mrs. Robinson[‡] have suggested that the classification of inventions should be based, not upon their immediate effect on the marginal productivities of different factors, but rather upon their eventual effect on these marginal productivities at that stage when all the investment induced by the introduction of the relevant invention has in the end petered out, assuming an absolutely elastic supply of capital, i.e. a constant rate of interest.

We propose to examine, on the basis of these definitions, what economic conditions tend to induce the emergence of inventions "saving" a particular factor.

If none of the factors considered is capital, the answer is obvious. A high price of a given factor tends to encourage inventions that economize it, while a low price of a factor tends to have the opposite effect.

If one of the factors is capital, however, the problem is not as simple as that. An all-over simultaneous proportional increase in the price of all the factors

[‡] R.F. Harrod's review of Mrs. Robinson's *Essays in the Theory of Employment*, *Econ. Journ.*, 1937. - J. Robinson, "The Classification of Inventions", *Rev. of Eco. Stud.*, 1938.

⁺ And what is regarded as a change in this "quantity".

other than capital would not stimulate the substitution of capital for all these factors at all, since it increased the prices of capital goods exactly in the same proportion. Even an all-over increase in the price of labour only, would tend to encourage the substitution of capital for labour to a very limited extent, since the prices of capital goods tended to go up nearly in the same ratio as wages did. This is so because the prices of capital goods largely consist, in ultimate analysis, of wage costs and of other items that tend to vary in the same proportion as wages do, such as interest on the capital invested in wages, certain taxes, the profit margin added to the former items etc. Of course, the item of land-rent costs included in the prices of capital goods, on the other hand, would not fall into this class. The same may be true for some other cost items. But these are hardly very important quantitatively.

On the contrary, high wages only for a special kind of labour (say for a special trade) not entering into the prices of capital goods may be a powerful encouragement for the mechanization of certain industrial processes, and for the emergence of appropriate labour-saving inventions.

At the same time, high wages in the capital-goods-producing industries tend expressly to discourage, rather than to encourage, the substitution of capital for labour, since they tend to raise the price of capital goods.

While the effects of the price of labour upon the substitution between labour and capital are much more problematical than often assumed, the effects of the price

of capital, i.e. of the rate of interest, pose no theoretical difficulty.[⌘] A low rate of interest (or a ready availability of capital) tends to encourage the substitution of capital for labour and the invention of labour-saving devices. The influence of the rate of interest tends, however, to be limited by the restricted "economic horizon" of business firms, that is, by the fact that, owing to the uncertainty of the future, they tend to require that their investments in equipment should pay for themselves within a few years. But even so, it is the level of the rate of interest (and the degree to which capital is easily available), rather than the general level of wages, which determines the extent to which capital is substituted for labour in any economy. The level of wages is more an effect of the use of highly capitalistic methods than its cause. The real cause is not the scarcity of labour, but rather the abundance of capital. ~~⌘~~

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The effect of economic demand upon the emergence of new inventions depends, of course, not only upon the

[⌘] It does raise, of course, the problem of Professor Hayek's "Ricardo Effect". But this will be disregarded, see, however, Hayek, *The Pure Theory of Capital*, pp. 377-396.

~~⌘~~ Owing to the peculiarity of the concept of capital, the scarcity or abundance of capital is expressed, not in its "relative" price in comparison with the price of other factors of production, but simply in its "absolute" price taken in itself, i.e. in the rate of interest.

nature of this demand itself, but also upon the factors governing the supply of inventions, viz. upon the technical possibility and facility of developing inventions that meet this demand, as expressed in the development costs of the corresponding inventions (see above pp.4-5). The effect of the economic demand for certain inventions consists in accelerating technical progress in a particular direction by directing resources in the appropriate fields of inventing and research. The investment of a given amount of resources, however, may be able to accelerate technical advance in one direction to a much greater degree than it would be able in another direction, since the solution of one set of problems may be possible at much lower costs than would be the solution of another set of problems (if possible at all).

In general, it is clear that the existence of an intensive economic demand is often a very powerful stimulus for the solution of a limited technical problem, say, for inventing substitutes for a certain raw material. There is no doubt that in secondary points such as what new materials are invented and the like, or even what new industries are created by inventions, the direction of technical progress greatly depends on economic demand.

But it might be doubted whether certain fundamental features of the technology of a given age and certain fundamental technological trends are very responsive to economic influences.

For instance, Mrs. Robinson^{*} is probably right that at the first stages of mechanization there was a

^{*} Robinson, Essays in the Theory of Employment, pp.134-135.

tendency to the prevalence of labour-saving inventions as new and new industrial processes have been taken over by machines, while at later stages technical progress rather tends to be "neutral", since at these stages further mechanization is likely to go on at the same rate in the capital-goods industries as it does in the other industries, so that the productivity of labour tends to increase at all "stages of production" at the same rate.[ⓧ] Of course, the physical quantity of the capital equipment continues to increase, but this factor is more or less exactly offset by an incessant fall in the prices of capital-goods^{ⓧⓧ} owing to the increasing productivity of capital-goods industries.

Now it is unlikely that economic factors, say, the abundance of capital, have had a great influence upon the degree to which technical progress has run in a "labour-saving" direction or the opposite at either of these two phases. A scarcity of capital would probably have prevented the Industrial Revolution at all, but it would hardly have been able to give technical progress a "capital-saving" bias at that time. At the present time, on the other hand, the abundance of capital can hardly divert this progress into a "labour-saving" direction, since it does not slow down the rate of the technical advance of the capital-good industries in comparison with the rate of technical advance in the other industries.

In a similar way, at early stages of industrialization technical progress has tended to substitute unskilled labour for the skilled labour of craftsmen. Probably at later stages there is an opposite tendency,

[ⓧ] Professor Hansen's "Stagnation Thesis" is based, besides other things, upon this tendency of technical progress to become less "labour-saving" and to absorb less capital than in the past (see e.g. A.H. Hansen, Fiscal Policy and Business Cycles).

^{ⓧⓧ} Both in terms of commodity units and of wage units.

since the routine operations performed by unskilled labour are especially suitable for mechanization. In the end most industrial processes may become completely automatic only needing the attention and the maintenance work of highly skilled technicians (we are, however, still far from this stage). It is unlikely that such technological trends can be influenced very much by the relative scarcity of skilled and unskilled labour.

Likewise, technical progress has tended continually to increase the optimum size of production units. There have been, of course, technical developments that have favoured the small producer, such as the invention of the cheap small-scale electro-motor. But even these developments have in most cases depended on the existence of large-scale production elsewhere in the economic system. For instance, the cheap electro-motor can be best produced by large firms with the help of mass-production methods.

We know that the predominance of large firms has been and is due not only to technological forces, but also to a number of institutional factors. But, it seems to me, what could be achieved in favour of small firms by institutional reforms is rather limited. I cannot, therefore, agree with Professor Röpke's argument that "even in the past...technical developments could have been steered in a direction which would have decreased the preponderance of large enterprises, and this is certainly possible in the future". * I do not think that technical progress can be to any great extent "steered" in this respect.

* W. Röpke, *The Social Crisis of Our Time*, pp. 136-137.

On the other hand, even if it is true that the development of technology tends to take a course determined, in some fundamental aspects, more by technical, than by economic, forces, the rate of its progress along this fixed route greatly depends on the amount of resources that economic forces make available for investment in inventing and research. Moreover, while technical development is not responsive to economic influences in some respects, it may be very responsive to them in others, as we have seen.

VI. The Problem of a Patent Reform.

So far we have been concerned with pure theory only. It seems, however, desirable to add a Chapter on an important problem of applied economics, viz. the question of a patent reform.

The question of patent rights arises, of course, only in a private-enterprise economy. In a socialist economy, in which both the research laboratories producing inventions and the industrial plants using inventions are public property, there is no scope for patent rights at all. But even in a private-enterprise economy, it may be doubted whether a private monopoly over the use of new inventions is the best solution from the standpoint of society.

While earlier economists had in general favoured the patent system, Professor Sir A. Plant was the first to subject it to a severe criticism in 1934.[Ⓜ] He has applied to it the familiar anti-monopoly argument of economic theory and has accused it of a considerable mal-allocation of resources. He has pointed out that the present patent system disturbs the allocation of resources engaged in production since it tends to restrict the output of commodities produced by patented methods and to retard the general use of the latest and best inventions. It also disturbs the allocation of resources engaged in inventing and in research, since it induces inventors to develop

[Ⓜ] Plant, "The Economic Theory concerning Patents for Inventions", *Economica*, 1934; see also his "The Economic Aspects of Copyright for Books", *ibid.*

patentable rather than unpatentable inventions, and inventions for industries with an inelastic demand rather than inventions for other industries. Moreover, it often makes it necessary for certain firms to invent methods alternative to some patented method, which is a pure waste if the latter method is satisfactory.

Professor M. Polanyi went a step further in 1944 by publishing a practical scheme for reforming the patent system. [⌘] He has recommended government rewards for inventors who would agree to giving up their patent monopoly. These rewards would amount to a fixed ratio of the social gain resulting from the relevant invention in each period of time (during the life of the patent). This ratio would be fixed, on the basis of trial and error, at a level high enough to induce a greater part of inventors to choose for themselves the government reward for which they are eligible instead of the patent monopoly. Professor Polanyi thinks that rewards equal to $1/3 - 1/10$ part of this social gain would suffice for this purpose. He proposes to require the users of an invention to give the inventors all the statistical information needed for making the calculation of this social benefit possible.

Professor Polanyi's scheme would avoid giving monopoly power to inventors (and to those who buy this power from them). At the same time, it does establish alternative rewards for inventors. He has clearly realized that the trouble with the present patent system is not the fact that it rewards inventing, but only the fact that these rewards cost not only the monopoly profits actually enjoyed by the patentees, but also the mal-allocation of resources resulting from the latter's patent rights.

[⌘] See his "Patent Reform", Rev. of Econ. Stud., 1944.

It seems to me, however, that Professor Polanyi does not go far enough in this direction when he recommends for inventors rewards equal only to a lesser part of the social benefit resulting from their inventions. It is a general principle that the private product of an activity should be made equal to its social product as nearly as possible. This would suggest higher rewards than those equal to $1/3 - 1/10$ part of this social benefit, even if allowance is made for practically inevitable inexactitudes in its calculation.

Professor Polanyi's scheme would, on the other hand, meet all of Professor Plant's objections only if it were extended also to those "inventions" that are not patentable at present, such as new organization methods or new animal and plant races etc., which seem to merit the same encouragement.

Moreover, besides the rewards for completed inventions proposed by this scheme, smaller bonuses might be established for mere ideas or uncompleted inventions that prove to be suitable for being further developed by government or private laboratories.

Furthermore, it would be desirable that the government should offer special prizes for future inventions serving an important specified social need. This has often been done in the past, but it should be made a regular usage undertaken in fixed intervals, say, once a year. (For example, it seems to me that inventions promoting cheap housing would at present time merit a special encouragement.)

I think that a greater use could also be made of moral rewards (decorations, public celebrations etc.) for

inventors and capitalists successfully engaged in research. Such things cost hardly anything and are very effective stimuli, human nature being as it is. It is an error to suppose, in my view, that the "logic" of capitalism allows only material rewards, and this is, of course, even less true in the case of a not purely capitalistic, but rather a mixed economy. Sociologists have often pointed out that the apparent exclusive profit-mindedness of the capitalist entrepreneur is due to the fact that profit is for him in most cases the only visible sign of success or failure. If he were given also a different criterion of success or failure (sufficiently backed by public opinion), then his behaviour could certainly be influenced through this channel, within certain limits.

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The theoretical argument against patent monopolies and for a patent reform can be best based, it seems to me, upon the Principle of Marginal Cost Pricing, recently developed by welfare economists. [⌘] Since the use of an invention, once it has been completed, does not entail additional social costs, it should not be made conditional on the permission of the inventor and on the payment of royalties. In every field in which marginal costs are negligible as compared with the fixed costs, there is a strong case for not charging the consumers any price and for defraying the fixed costs out of government funds. This clearly applies to inventions.

[⌘] An excellent summary of the controversy that has occurred about this principle is found in N. Ruggles, "Recent Developments in the Theory of Marginal Pricing", Rev. of Econ. Stud., 1949-50.

The only problem is whether the government should bear the costs of inventions, only through financing research directly (in government research organizations), or rather also indirectly through rewarding the inventors, and the financial backers, of successful inventions. Both methods seem to be necessary. Some useful research projects would probably be unattractive for private capital even under Professor Polanyi's scheme, because they took too long a time for completion, or because they required too much capital, or because their main use did not lie in the commercial field. In such cases the government should step in.

On the other hand, it is undesirable to concentrate the power of deciding the merits of different possible research projects in the hand of the government alone, that is, the power of making decisions in a matter in which no reliable forecasts are possible. It is very important that private entrepreneurs should be given every encouragement to choose research projects for development as they think fit and, in particular, to take up, at their own risk, projects not undertaken by the government research organizations. The general arguments in favour of private enterprise in risky pioneering ventures apply, in the case of research, with special force.

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A special institutional argument for a patent reform is the fact that patent rights are often used, not so much for earning a monopoly profit on the use of the patented invention, but rather for entrenching the monopoly power of a certain interest group within a particular industry. Not only the patents of the methods actually used but also the patents of the existing alternative methods are bought up, and these patents are used to make it impossible for competitors to enter the industry.

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Professor Polanyi, wisely enough, recommends a gradual transition towards his scheme. He does not want ^(to abolish) the patent monopoly of inventors, but rather wants to induce them by an adequate compensation to give it up voluntarily. His scheme, as it stands, has, however, also another merit than gradualness. It makes it possible for inventors, to retain their patent monopoly instead of converting it into a right for government rewards in cases when their inventions are such as to be unlikely to be put into use by entrepreneurs in the absence of a guaranteed monopoly for their use. Some useful devices are too risky to be put into practice without the hope of exceptionally high monopoly profits. Others require a temporary protection from competition because their utilization pays only on a sufficiently large scale, owing to indivisibilities. Such inventions can be used only by government or private monopolies. But, if their introduction is a rather risky venture, it seems to be preferable to grant a monopoly for a private capitalist to introduce them.

Under Professor Polanyi's scheme the government would have the power to compel patentees, if necessary, to convert their patent monopolies into a right for government rewards. In effect, it seems to be desirable to grant this power to the government. But this power should not be employed, in my view, in cases when the practical use of an invention can be secured only by giving its first user a temporary monopoly. On the other hand, it could be safely employed in every case where a competitor makes an offer to the government to put the invention into use on a reasonable scale without being granted any monopoly right. It goes without saying that in this case the inventor would have to be compensated by government rewards proportional to the actual use of his invention along the general lines of Professor Polanyi's scheme.

A P P E N D I X.

The Extension of Economic Analysis to

Human Activities Outside of the Field of Business Life.

Professor Robbins has received a good deal of criticism for defining economic science, not as a science which considers a particular institutional sector of human behaviour (viz. business), but rather as a science which deals with human behaviour in general, though having regard to only a particular aspect of it (viz. as far as it involves the allocation of scarce means among competing uses). His definition has been objected to on the ground that it fails to delimit the subject-matter of economics from that of the other social sciences. Little serious consideration has, however, been given to the possibility that the field in which economic analysis can be profitably applied may extend in fact over a considerable part of the territory of some of these other social sciences. Even Professor Robbins has gone no further than to point out the presence of an economic aspect in every deliberate human action, but he has never regarded, either, this economic aspect of non-commercial human activities important enough to make their analysis by the methods of economic theory worth while.

In other cases, also, economists and other social scientists have often indicated structural similarities between processes within the institutional framework of the market economy and between other social processes - without exploiting, however, the methodological possibilities implied by them. [‡]

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[‡] For instance, the parallelism between a one-party system and a monopolistic market, or the one between a many-party system

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It is a remarkable fact that cultural anthropology and sociology have recently adopted as their main analytical tool a method that has a close affinity to the economic approach - viz. the "functional method" - without being directly influenced by economics (they have in fact acted rather under the influence of biology), indeed without even realizing this affinity.

The functional method consists in analysing any social institution in terms of its "social function", i.e. in terms of the social needs it satisfies. This comes, however, very near to analysing it in terms of "utility", as the economist would do.

In any case, an explicit, instead of an implicit, use of the conceptual tools of economic science could greatly contribute to the clarification of the conceptual framework of the functional method.

(Continued from p. 81.)

and a competitive market has been noticed already by Marx, and has recently been admirably re-elaborated by Professor Schumpeter in his "Capitalism, Socialism and Democracy". Certain empirical facts about the relation among the political platforms of competing parties have been accounted for by Professor Chamberlin on the basis of his concept of "product differentiation".

Among political scientists, Professor G.E.J. Catlin likes to stress the similarity between some political and some economic problems (cf. his "The Science and Methods of Politics" and "A Study of the Principles of Politics"). A special reference must be made to Professor Duncan Black, who has worked out a Theory of Committee Decisions by means of methods similar to those used in economics and has claimed on this ground to have established the fundamental unity of the economic and the political science (Journal of Political Economy, Feb. 1948 and Economic Journal, Sep. 1950). Since, on the other hand, a model

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In its present form, the functional method lacks any well-defined causal theory. No explanation is given how social needs come to give existence to social institutions able to satisfy them.

Moreover, no clear distinction is made between the subjective "wants" governing human behaviour, and the objective social "needs" rooted in the biological requirements of the human organism (e.g. the need for food) or in the functional requirements of social co-operation (e.g. the need for some kind of language). The "social function of an institution" is meant to include both its role in the gratification of subjective wants and its role in the satisfaction of objective social needs not manifested in subjective wants. But such a broad definition of this concept greatly reduces its explanatory value, for objective social needs have a positive causal influence upon social institutions only as far as they find expression in subjective wants. If they do not, the frustration of important objective social needs may possibly impair the vitality of a community or disturb its normal functioning, but cannot call forth positively the social institutions required for the satis-

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based on "committee decisions" is - unfortunately enough - only applicable to a limited field of political life even in the case of democracies, it must be supplemented by more realistic models that represent some more fundamental, even though less pleasant, aspects of politics, especially the part played by the factor of force, which can, however, be analysed no less profitably with the help of tools borrowed from economics.

Among sociologists, Max Weber has pointed out the analogy among the processes of increasing "rationalization" in business, public service and other organizations.

faction of these needs. For instance, the biological need for sanitation resulted in appropriate institutions only after the realization of this need and after the emergence of a want for its gratification.

But even conscious wants do not directly result in social institutions capable of their gratification. Schumpeter's proposition about the need for an entrepreneur is valid not only in business life. It is true in almost every sector of human life that social institutions are seldom established by the prospective "consumers" of their services, but that the initiative usually comes rather from a kind of "entrepreneur", such as a social reformer, cultural innovator or the like. This may aim simply at the satisfaction of a generally felt "manifest" want. But he may just as well himself create the want he gratifies out of the raw material of "latent" social needs. Social wants, and even more, not-yet-realized social needs, that did not find an "entrepreneur" who created the mechanism for their satisfaction would have to go indefinitely without gratification.

At the same time, the concepts of manifest social wants and of latent social needs remain very vague as long as they are not made quantitative, at least in a very rough and ready sense. This once more requires that a recourse should be made to the concepts of economic science. Manifest wants must be described by means of a kind of demand schedule expressing the amount of resources people would be ready to give up for their satisfaction under different cost conditions. Latent needs, on the other hand, must be characterized by the amount of resources needed for making them manifest (by propaganda etc.) and by the manifest demand schedule thus created.

Finally, the proposition that the social function of an institution consists in the satisfaction of certain "social" wants (or needs), fails to make it clear precisely whose wants or needs are served by this institution, and how these benefits

are distributed among them, i.e. it tends to hide the conflict of interests among the different individuals and groups of the society. It also fails to bring out the fact that one and the same person may have conflicting interests, of which some are served and some are thwarted by a given institution - especially the fact that the same individual's short-run and long-run interests may be very different. This problem can again be best analysed by economic methods, in particular by the methods of welfare economics (which should not be regarded exclusively as a theory of general social interests, but rather as including the theory of sectional, group and individual, interests, as well).[ⓧ]

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In connection with the application of economic analysis to different sectors of social life, it seems to be advisable to adopt a narrower definition of the economic aspect of human behaviour, and of the scope of economic analysis should rather be restricted to human activities which involve a choice among competing ends so that this choice is dependent to a significant degree upon the comparative opportunity costs of these different alternatives, i.e. this choice must have a non-negligible "opportunity-cost elasticity". (This last concept is a generalization of the usual concept of the price elasticity of demand, and has a close affinity to the Marshallian Principle of Substitution.)

[ⓧ] Professor R.K. Merton gives a very well-balanced criticism of the functional method in his "Social Theory and Social Structure", but he does not relate it to the conceptual framework of economic theory.

This definition excludes purely "technical" decisions which do not require a choice among competing ends, in the same way as Professor Robbins' definition does. But, in addition, it also excludes human actions which, though formally involving an allocation of scarce resources among alternative uses, are not, at the same time, dependent on the comparative opportunity costs of these alternatives to a significant degree. For instance, a painter may choose to work in one artistic style rather than in another without any regard to how his decision affects the salability of his future works and their production costs in terms of time, effort and money (viz. his expenditure on materials). Under this assumption, owing to the opportunity-cost inelasticity of this choice, very little could be gained by subjecting it to economic analysis, in spite of the fact that it clearly involves the allocation of the artist's scarce time, effort, money and earning power among alternative uses.

Of course, activities inelastic in relation to their own opportunity costs may still be subject to the influence of economic forces in other, more indirect, ways. They may have quite a significant "cross elasticity" in relation to changes in the opportunity costs of other human activities. For instance, a rise in the opportunity costs of travelling abroad (whether in terms of money or in terms of political molestation) may markedly alter the style of the painter of our previous example by depriving him of foreign influences. Moreover, nearly every human activity has a considerable "income elasticity", at least in relation to large variations in income. For example, a substantial fall in our painter's income would probably compel him either to commercialize his art or to look for another occupation.

The importance of many indirect economic influences of these kinds upon human behaviour has been pointed out, (often with some exaggeration) by Marxist writers.

However, the analysis of these indirect influences seldom requires the formal tools of economic theory. The only problem with them is usually the question of fact, i.e. the question whether they exist and what their importance is in a given case.

This narrower definition of economic analysis excludes a considerable sector of human activities from the field of application of this analysis. Many cultural activities especially, such as play, recreation, art, religion, pure science etc., tend to have a very low opportunity-cost elasticity. They tend to be governed by the prevailing cultural patterns (value attitudes) and by the psychological factors responsible for variations in these patterns, i.e. by the forces of demand, alone, and to be fairly independent of the costs they entail within quite a wide range of variation of the costs. (Their behaviour can be compared to that of a commodity with a completely inelastic demand curve, the production and consumption of which commodity are completely determined by the position of this inelastic demand line and are independent of the position and shape of the unit cost (supply) curve.)

But demand, and the cultural and psychological forces underlying it, are "data" for economic analysis. (Except in so far as they are subject to "indirect" economic influences, see above. Their explanation must be left to cultural anthropology and to social psychology. Since in the field of the mentioned cultural activities everything depends upon demand alone, economic analysis has nothing to contribute to their causal explanation. (Still, the conceptual framework of economic science could be of some use, even in these fields, on a purely descriptive level. The concept of value attitudes in anthropology and psychology often suffers from the lack of precise, let alone quantitative, meaning. It would greatly promote conceptual clarity if value attitudes were always described in terms of a system of

preferences and indifferences along the lines of economic theory.)

The cost aspect tends, however, to be important in the case of every cultural or other human activity that needs expensive equipment or the work of full-time specialists (other than members of the leisured classes) or, especially, that requires large-scale organization. Such activities are governed, not by demand alone, but by the interaction of demand and of cost considerations. They cannot, hence, be explained by the mere methods of cultural anthropology and of social psychology, but also need analysis in economic terms.

For instance, the internal organization of a large-scale organization - social, occupational, cultural or any other - and the external results it is able to achieve are the product of two factors. One is the demand schedule for the services of the association as expressed by the amounts of money, of effort and of other resources that the members of the association (and possibly outsiders) are ready to contribute under different cost situations. [¶] The other is the cost schedule expressing the "costs of production" of the different items of the internal organization of the association and the "costs of production" of the external results it aims at, in terms of money, effort and other resources.

The shapes of the demand and of the cost schedules of the services of a given association greatly depend on whether it works in close competition with other associations or not. In

[¶] The problem is complicated by the fact that an association can influence the contributions of its members and other benefactors by propaganda, in the same way as a business firm can influence its sales curve by advertisement.

effect, the theory of associations would be a fruitful field of application for the economic theory of the different market forms. -

The field, however, which seems to promise the largest returns for economic analysis - apart from business life - is the field of politics. It is a fundamental aspect of political life that people divide their scarce resources - their money, effort and so on - on the one hand between political and non-political uses, and on the other hand among their different political goals, with quite a close attention to the opportunity costs. Of course, the resources that can be used for political purposes often comprise, not only the resources familiar from economic theory, but also political rights (such as the right to vote and different forms of political authority), informal political influence, military power etc. I hope to be able to show, in a future essay of mine, that the theory of political equilibrium (of the balance of power) is capable of formalization as a theory of a special kind of "maximizing behaviour", quite comparable to the theory of the equilibrium of a market economy. The main use of a formal theory like this would be to facilitate the understanding of the complex interaction of political forces - just as the main use of the usual formal economic theory is to facilitate the understanding of the complex interaction of market forces, which would be hard to disentangle on a mere common-sense level.

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B I B L I O G R A P H Y .

To Chap.I.

- C.E.Ayres, The Theory of Economic Progress, Chapel Hill, 1944.
- E.Hahn, Das Alter der wirtschaftlichen Kultur. (How Old Is the Economic Aspect of Culture?) Heidelberg, 1905.
- F.A.Knight, Risk, Uncertainty, Profit. London, 1939.
- " "The Quantity of Capital and the Rate of Interest", Parts I-II, Journ.of Pol.Ec., 1936.
- " "Diminishing Returns from Investment", Journ.of Pol.Ec., 1944.
- " "Note on Dr.Lange's Interest Theory", Rev.of Ec. Stud., 1937.
- O.Lange, "Interest in the Theory of Production", Rev.of Ec. Stud., 1936.
- " Reply to Prof.Knight's "Note", Rev.of Ec.Stud., 1937.
- A.Marshall, Principles of Economics, 8th Ed., London, 1930.
- J.A.Schumpeter, The Theory of Economic Development. Camb., Mass., 1934.
- " Business Cycles. N.Y. 1939.
- " Capitalism, Socialism and Democracy. London, 1950.
- A.Smith, Wealth of Nations. London, 1874.
- D.McC.Wright, The Economics of Disturbance. N.Y., 1947.
- A.Young, "Increasing Returns and Economic Progress", Ec. Journ., 1928.

To Chapters II. and IV.

- J.B.Baker, Science and the Planned State. N.Y., 1945.
- A.K.Berle and L.Spragne de Camp, Inventions and Their Management. Scranton, Penns., 1951.
- J.D.Bernal, Social Functions of Science. London, 1939.
- F.R.Bichowsky, Industrial Research. Brooklin, N.Y., 1942.
- R.S.Edwards, Co-operative Industrial Research. London, 1950.
- A.P.M.Fleming, Industrial Research in the U.S.A. London, 1917.
- P.Freedman, The Principles of Scientific Research, Washington, D.C., 1950.
- C.C.Furnas, Research in Industry. Its Organization and Management. N.Y., 1948.

- S.C.Gilfillan, The Sociology of Invention. Chicago,1935.
H.S.Hatfield, The Inventor and His World. London,1948.
F.H.Heath and A.L.Hetherington, Industrial Research and
Development. London,1945.
D.B.Hertz, The Theory and Practice of Industrial Research.
N.Y.,1950.
H.Jerome, Machanization in Industry. N.Y.,1934.
P.Meinhardt, Inventions,Patents and Monopoly. London,1945.
R.K.Merton, "Fluctuations in the Rate of Invention",
Quart.Journ.of Ec.,1935.
F.W.Ogburn, Social Change. N.Y.,1922.
H.Poincaré, Foundations of Science. N.Y.,1913.
Standard Oil Development Co.,Ed., The Future of Industrial
Research. N.Y.,1945.
F.W.Taussig, Inventors and Money Makers. N.Y.,1915.

To Chap.III.

- K.E.Boulding, Economic Analysis. N.Y.,1941.
J.Chamberlin, The Theory of Monopolistic Competition.
Camb.,Mass.,1947.
W.J.Fellner, Competition among the Few. N.Y.,1949.
N.Kaldor, "Mrs.Robinson's "Economics of Imperfect Competition",
Economica, 1934.
" "Economic Aspects of Advertising". Rev.of Ec.Stud.,
1950.
M.Kalecki, "The Principle of Increasing Risk", Economica,1937.
B.S.Keirstead, The Theory of Economic Change. Toronto,1948.
O.Lange, "A Note on Innovations", Rev.of Ec.Stat., 1943.
A.Marshall, o.c.
J.Robinson, Economics of Imperfect Competiti on. London,1933.
T.de Scitovsky, "A Note on Profit Maximization", Rev.of Ec.
Stud.,1943.
A.Sherrad, "Advertising,Product Variation and the Limits of
Economics", Journ.of Pol.Ec.,1951.
P.M.Sweezy, "Demand under Conditions of Oligopoly", Journ.of
Pol.Ec.,1939.
R.A.Triffin, "Monopolistic Competition and General Equilibrium
Theory", Camb.,Mass.,1947.

To Chap.IV. See above p.95.

To Chap.V.

- G.F.Bloom, "A Note on Hicks's Theory of Invention", Amer.Ec. Rev., 1946.
- G.Cassel, The Theory of Social Economy. London, 1923.
- A.H.Hansen, Fiscal Policy and Business Cycles. N.Y., 1941.
- R.F.Harrod, Review of Mrs.Robinson's Essays in the Theory of Employment. Ec.Journ., 1937.
- F.A.Hayek, The Pure Theory of Capital. London, 1950.
- J.R.Hicks, The Theory of Wages. London, 1932.
- " "Distribution and Economic Progress: A Revised Version", Rev.of Ec.Stud., 1936.
- O.Lange, "A Note on Innovations", Rev.of Ec.Stat., 1943.
- A.C.Pigou, Economics of Welfare. London, 1920.
- J.Robinson, "The Classification of Inventions", Rev.Ec.Stud., 1938.
- " "Essays in the Theory of Employment. London, 1937.
- W.Röpke, The Social Crisis of Our Time. London, 1950.

To Chap.VI.

- P.Meinhardt, o.c.
- C.S.Parsons, Patents, Designs and Trademarks. London, 1938.
- A.Plant, "The Economic Theory concerning Patents for Inventions", Economica, 1934.
- " "The Economic Aspects of Copyright on Books", Economica, 1934.
- M.Polanyi, "Patent Reform", Rev.of Ec. Stud., 1944.
- N.Ruggles, "Recent Developments in the Theory of Marginal Cost Pricing", Rev.of Ec.Stud., 1949-50.
- U.S.A.Temporary National Economic Committee, Final Report and Recommendations. Washington, D.C., 1941.

To Appendix.

- D.Black, "A Theory of Committee Decisions", Journ.of Pol.Ec., 1948.
- " "The Unity of Economic and Political Science", Econ.Journ., 1950.
- K.E.Boulding, "Is Economics Necessary?", in Centennial, Collected Papers etc., American Assoc.for the Advancement of Science. Washington, D.C., '50.

- G.E.J.Catlin, The Science and Method of Politics. London, 1927.
" A Study of the Principles of Politics. " 1936.
- W.Eucken, The Foundations of Economics. London, 1950.
- B.Malinowski, "Culture". Encyclopedia of Social Sciences.
Vol.4 pp.621-645. N.Y., 1931.
- R.K.Merton, Social Theory and Social Structure. Chicago, 1949.
- T.Parsons, The Structure of Social Action. N.Y., 1937.
- L.C.Robbins, Essays on the Nature and Significance of
Economic Science. London, 1949.
- J.A.Schumpeter, Capitalism, Socialism and Democracy. London,
1950.
- M.Weber, General Economic History, Translated by
F.H.Knight, London, 1927.