

WORKING PAPERS IN ECONOMICS

**The Road to Full Employment:
Co-ordination in a World of
Interdependent Decisions**

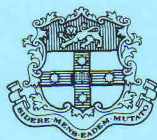
by

Flora Gill

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CONTENTS	PAGE
1. Introduction	1
2. Perspective	4
3. Atomistic conduct - impeccable coordination or a long wait for Godot?	13
4. Contemplating the agenda for public policy	26
5. A Delicate Economic Balance	29
6. Conclusion	32
References	36
Addendum	40

The Road to Full Employment: Co-ordination in a World of Interdependent Decisions

1. Introduction

The modern capitalist is a fair weather sailor. As soon as a storm rises, he abandons the duties of navigation and even sinks the boats which might carry him to safety by his haste to push his neighbour off and himself in. - Keynes 1932: 335.

Many Western countries, including Australia, have been saddled with a very poor level of national investment for a number of years. There is little doubt that without a substantial recovery in the national level of economic activity the likelihood of full employment recovery is extremely dim. Standard microeconomic theory would diagnose the disease as the result of 'wrong' relative prices, and prescribe the cure as setting 'correct' relative prices, specifically by cutting wages. This view, it seems, has increasingly influenced policy making. The present paper seeks to challenge the tendency to see 'wrong prices' as the universal root cause of unemployment, emphasising the need to seriously consider the possibility that unemployment is a case of coordination failure due to interdependence of the timing of investment projects.

This does not mean that all episodes of low level macroeconomic activity can be traced to this particular root cause. Rather, the aim is to introduce into the debate a Keynesian element which is focused on coordination failure which is not necessarily traced to price rigidity.

My specific concern in this paper is with the prospects for investment recovery in an economy which is in the throes of recession. My principal proposition is that interdependence of decisions is a vital aspect of the dynamics of macroeconomic adjustment, and that such interdependence can explain a failure to break through. That is, an economy may be in dire straits not because it lacks properties which are essential to the equilibrium it seeks to reach, but rather it does not have the means to get there. The challenge that this poses for public policy is to facilitate the emergence of (or the access to) the right dynamic adjustment path.

In more specific terms, the argument is that the (individual firm's) decision whether to invest now or wait for a brighter day depends crucially on the proportion of firms (ie the presence of a critical mass) it believes to be embarking on significant investment projects. Using a simple game-theoretic framework, I argue in this paper that an economy can find itself in a stalemate simply because each agent is waiting for the others to move first. This may or may not be directly linked with poor levels of effective demand. The issue is not one of having an adequate *level* of effective demand *per se*, but rather of it having a particular *quality*. Effective demand, the present paper posits, will perform its 'Keynesian' role only if it successfully operates as a signalling mechanism, convincing a sufficient number of individual agents that a critical mass of agents is set to embark on substantial investment projects. If it achieves this, the increase in the level of effective demand will break the impasse.

Convincing a sufficient number of firms that a critical proportion of businesses are embarking on substantial investment projects is tantamount to achieving an explicit contract among businesses to *coordinate* the timing of their investment across a wide range of enterprises. For Keynes, I am convinced, protracted recession is a manifestation of coordination failure in a system based on atomistic conduct. This is suggested not only as one possible reading of the General Theory, but also as an undertone in many of his writings during the '30s (eg Keynes (1932)).

In game theoretic terms, a judicious demand management strategy which successfully establishes a coordination mechanism can be described as providing the mechanism necessary to attain an optimal solution in *coordination/assurance game*, where each 'player' must be assured that their actions are indeed properly coordinated.¹ As described in the following section, this paper has affinity with the analysis of demand spillover effects (e.g. Gale, 1995; Shleifer 1886).

The present paper illustrates the coordination problem with a standard two-person non-cooperative game, which yields two Nash equilibria in pure strategies, one of which is Pareto dominated by the other. This story of a two-person game with discrete payoffs is then converted to a game with a continuum of players each facing continuous payoffs. Drawing on both Schelling's neighbourhood tipping model and the analysis of network externalities in the industrial organisation literature to highlight the role played by decision interdependence (which takes the form of dependence on the behaviour of a critical mass of the relevant population) the paper shows the number of possible equilibria is increased. The analysis draws attention to particular dynamic properties of such interdependence, and outlines a framework for

¹ See Collard (1978) on the relationship between coordinating behaviour and assurance games.

breaking coordination failure. Specifically, unstable equilibria, have some desirable *take-off* properties which should be exploited by public policy.

2. Perspective

Suppose we somehow establish a consensus that wage cuts are indeed a necessary condition for recovery to full employment. It does not follow that this is a sufficient condition. In this paper I will go further, arguing that wage cuts alone cannot restore the economy from its malaise. They will not readily lead to substantial employment growth, neither will they provide an autonomous stimulus to investment on the requisite scale.

To put this more bluntly, well qualified labour could be handed to employers on a platter as a free gift, and yet they might turn it down. An offer which in a buoyant economy would have been seized upon with glee will be met with utter indifference when the prospects of selling the final output are poor. Thus, while overly high wages can ultimately drive an employer offshore, a sharp reduction in the wage level may well fail to rescue the economy from the low investment/low employment trap. In fact, if this is the only major initiative, or even the first in a sequence of steps, it is possible that it will make things worse. One reason for this is that supply side measures can be rather ineffective unless they are accompanied by demand side measures.² However, what I wish to explore today is neither the question of the adequacy of effective demand *per se*, nor whether or not we are 'capacity constrained'. Rather, I wish to raise an altogether different issue - could we actually be 'process constrained'?

² In this context, wage cuts on their own may nullify favourable supply side effects by drastically reducing the level of effective demand.

I define as 'process constrained' the situation where the economic system fails to unleash a dynamic adjustment process capable of successfully leading it to a socially desired state.³ The issue does not hinge on prices being 'wrong' - they may even be 'right'. Rather, the problem is the absence of a 'right' response in the 'quantities' domain.

Neither partial equilibrium theory (the theory of the firm) nor General Equilibrium theory⁴ readily alert us to the possibility of being 'process constrained'. In the case of the first, the reason is its reliance on the representative agent reduction of the macroeconomy; for the second the reason is its focus on the features of the 'destination' state itself (the nature of the conditions for the existence, uniqueness and stability of equilibrium) not on the dynamic adjustment path onto which an economy which has been 'jolted out of equilibrium' has been thrown.⁵

Every so often in the public debate on economic policy, we come across economists who still appeal to the theory of the firm to support a recovery strategy which relies simply on wage cuts. There is much to be questioned about this response to large scale unemployment.⁶ Here I wish to focus on only two issues - the partial equilibrium nature of the analysis, and the related fact that the argument is constructed within a representative agent model of the macroeconomy. To put this somewhat differently, sole reliance on the theory of the firm requires the assumption that

³ This desired state can even be defined in the simple terms of Pareto dominance.

⁴ Arguably, general, and partial equilibrium theories dominate our frame of conceptualisation of 'market forces'.

⁵ We tend to draw policy propositions from comparative statics analysis, with little if any concern for whether the economy can actually generate a path between the 'old' and the 'new' (post parameter change) equilibrium. We place our faith in stability conditions, treating them as if they actually were dynamic convergence propositions.

⁶ On the nature of the Australian experience with unemployment, and the policy response, see Aspromourgos and Smith (1995) and Gill (1995).

individual firms are guided by a set of constraints which map to a 'smooth downward sloping strictly stationary demand curve', with the level of the wage as the sole binding constraint on the number of workers that each employs. In addition, by its very nature, a representative agent model posits that the complex system called *the economy* can be collapsed into a giant representative agent without analytical loss. These assumptions are very problematic, not only because they employ partial equilibrium analysis when the core issue is one of general equilibrium, but also (as Kirman (1992) points out) they bring in through the back door an array of dubious assumptions. A most unfortunate feature of the array of representative agent models, which have been spawned by the search for microeconomic foundations of macroeconomics, has been their elimination of any chance to identify a macroeconomic malaise as a coordination failure (for which we need at least two agents). As Kirman (1992) observed when probing the concept of a representative agent:

*"Paradoxically, the sort of macroeconomic models which can claim to give a picture of economic reality (albeit a simplified picture) have almost no activity which needs ... **coordination**. This is because typically they assume that the choices of all the diverse agents in one sector - consumers for example - can be considered as choices of one 'representative' standard utility maximising individual whose choices coincide with the aggregate choices of the heterogenous group."*

[emphasis added] - *ibid.* p. 117.

He then continues, referring explicitly to the case of unemployment:

*"... the use of representative agent models leads to conclusions which are usually misleading and often wrong. Why is this? First, such models are particularly ill-suited to studying macroeconomic problems like **unemployment, which should be viewed as coordination failure.**"*
[emphasis added] - *ibid.* pp. 117-18.

The above discussion, brief as it may be, should help to explain the serious misgivings I have about policy analyses which invoke the theory of the firm as their basis. In summary, my misgivings are twofold. The first is the theory's common appearance in the garb of a representative agent model which *ipso facto* obscures the possibility of coordination failure. The second is the (related) fact that prices, factor prices in particular, are axiomatically treated as binding constraints. The possibility that other factors, rather than wrong prices, are the binding constraints is simply not considered.

Turning back to General Equilibrium theory, economists frequently see stability analysis as a sound description of dynamic adjustment paths, implicitly treating stability conditions as if they were synonymous with dynamic adjustment theorems. Yet it has been emphasised for some time now that stability and dynamic convergence theorems are very distinct analytical entities (Arrow 1959, Hey 1979, Fisher 1983). Increasingly, it has been recognised that stability theorems which are formulated within the Walrasian framework do not provide a convincing description of what is likely to happen in a real world setting where, being devoid of the services of the mythical auctioneer, trade *does* take place at non-market clearing prices.

These analytical propositions were pioneered by Kenneth Arrow nearly four decades ago in his seminal work *Towards a Theory of Price Adjustment* (1959). Arrow starts his discussion with two fundamental observations: first, price-taking, and therefore perfect competition, can exist (if at all) only when the economic system is in market clearing equilibrium, with the corollary that when the system is out of equilibrium, the short side of the market enjoys market power (Arrow 1959: 46). His second observation calls attention to the fact that economic theory contains a major vacuum as far as the analysis of dynamics is concerned. Dynamic adjustment models, such as Samuelson's (1949), which shows that if prices change as a linear function of excess demand their values ultimately reach the 'market clearing level', are not supported by any explicit choice-theoretic account; there is no description of rational profit (utility or whatever) maximising agents whose behaviour generates the posited relationship between the magnitude of price change and excess demand (Arrow 1959:43).⁷ Arrow's study is a plea which is eloquently summed up by the title of his article - a theory of price adjustment is badly needed. This plea has not been left unheeded, but as Hey concludes⁸ in 1979, quoting Franklin Fisher:

"As Fisher himself remarks (after struggling manfully with a most impressive paper designed to tell a story with a competitive ending)
'Depending partly on one's predilection, however, the story may seem rather less than more sensible, and, indeed, one way of looking at the

⁷ In more familiar terms, Samuelson's dynamic equations can be described as a *reduced form model* which is not underpinned by a set of *structural equations*.

⁸ To my reading, the results of the research which are summed up by John Hey suggest that the focus on equilibrium conditions, and the fact that the information problem has been abstracted from the analysis (by the analytical function assigned to the Walrasian auctioneer), has created a false impression of the scope for perfectly competitive price levels. Trade at disequilibrium, as Arrow predicted, always involves market power. What has subsequently been established analytically is that this market power is not likely to vanish once the price system is in 'market clearing equilibrium'.

results is as showing how hard it is to tell a sensible competitive disequilibrium story' " (1973, p. 448). - Hey, 1979, p. 181.

There is, however, more at stake when we shift the focus of analysis from *stability* to *dynamics*. As Fisher points out, once attention had been focused on the investigation of the issue of the dynamic adjustment path, we must consider the possibility of having multiple equilibria which are path-dependent (Fisher 1983:14-16).⁹

A natural question follows: can path-dependence lock an economic system into an unfavourable equilibrium. The answer, it has been shown, is 'yes'. The pioneering work of Paul David (1985, 1988) and Brian Arthur (1984, 1990) has persuasively demonstrated that path-dependence can lock an economic system (the economy at large, an industry, or any other group of agents) into a Pareto-inferior equilibrium. More recently, Cooper et al (1990) address this issue in a game-theoretic framework, where the possibility of having multiple equilibria has spawned an interest in the question of *equilibrium selection*. The selection of the equilibrium, their experimental results showed, did not fall on the equilibrium with the dominant payoff (Cooper 1990: 226). Similarly, Van Huyck et al (1990) show that their experimental examination of the dynamics of equilibrium selection provided examples of coordination failure which resulted neither from the conflicting objectives of the prisoner's dilemma games nor from asymmetric information, but

⁹ More precisely, the growing belief among economists that the possibility of multiple equilibria must be seriously contemplated, and the recognition that there is a significant difference between stability and dynamic convergence analysis, have together led to the question of whether we have path-dependent equilibria. In other words, the question of whether a particular equilibrium is attainable depends on the dynamic path itself.

from what they describe as strategic uncertainty, which affects the dynamic path of equilibrium selection (Van Huyck et al, 1990: 247).

One of the key factors which generate inferior path-dependent equilibria is the presence of *network externalities*. When these play a significant role, the optimal value of an individual's choice variable depends crucially on the actions of other agents in the 'network'. An often cited example is that of telephones. The value of owning a telephone obviously depends on the number of friends and business contacts who own a telephone. When the proportion of friends/business contacts who have a telephone is significantly below 1.0, the benefit derived from having a telephone will vary with the size of this proportion. David's (1984) QWERTY model has attracted attention to the significant influence of network externalities on technological choice.¹⁰ Cooper and John (1991: 14) have pointed out that Keynesian demand constraints can be understood as a manifestation of demand externalities which are 'brought about by demand linkages that individual firms do not internalise'.

Network externalities exist whenever a decision of one economic agent depends on the proportion of agents (in the relevant 'network') who have chosen the same option. The choices of technology, or the decision to own a durable such as a telephone, are but two examples of a much larger and more diverse class of decisions.¹¹ Nearly a quarter of a century ago, Thomas Schelling (1972) presented an elegant model which sets out to analyse the dynamics of residential movements in a

¹⁰ He argues persuasively that the standard keyboard is an example of a technology which gained dominance despite its proven inferiority to the Dvorak keyboard, which became available within a few years of the invention of the typewriter in the late 19th century. The first mover won the contest simply because most typists had already become accustomed to the QWERTY layout and this discouraged the spread of the alternative design. Schelling (1978:122-123) foreshadows this proposition.

¹¹ Network externalities have also recently gained prominence in the industrial organisation literature (see Tirole (1989)).

situation where the individual decision to either stay in a neighbourhood or leave it depends on the proportion of other individuals who have already moved out.¹² As Schelling (1978) later demonstrated, this model can be generalised to a much larger class of interdependent decisions, a fact which we use in the analysis offered in the present paper.

The possibility of having multiple equilibria, and the scope for facing coordination failures which make Pareto-dominated equilibria feasible, has also been addressed in the macroeconomic literature, specifically by a significant number of studies within what has come to be known as the New-Keynesian school. Cooper and John (1991) show that the notion of 'coordination failure' is present even in a range of papers which do not refer to this term explicitly. New Keynesian models, however, are focused not so much on interdependence in the choice of quantity *per se*, but rather on interdependence in pricing behaviour of the type which can give rise to nominal and/or real price (including wage) rigidity.¹³ Their essence, therefore, tends to be a failure to coordinate price changes, maladjustment in the quantity domain being a consequence phenomenon. In addition, this literature focuses on the conditions which can give rise to specific multiple equilibria, with only tangential attention being paid to the dynamics of equilibrium selection. Dependence of behaviour on what a critical mass of other agents does, does not seem to have been at the core of the macroeconomic literature. A notable exception to this is the work by Shleifer (1986)

¹² Schelling found that the moments of the probability density function (p.d.f.) of the reservation values of the proportion of movers play a crucial role in determining whether the suburb ultimately reaches a stationary state as a racially mixed suburb or a strictly black one. It established that in principle there is a whole spectrum of possible stationary states lying between the only two (lily white and carbon black) which featured in the public debate.

¹³ For a comprehensive description of the core of the New Keynesian literature as being focused on endogenising price rigidity, and sustaining its identification as the cause of macroeconomic instability, see Hargreaves Heap (1992), especially chapters 5 and 6 (and also 1).

and Shleifer et al (1988, 1989), where an economy ‘... can settle into a very bad equilibrium’ (Shleifer 1986: 1165), with the prime mover being demand spillover effects, not price rigidity.¹⁴ A very recent paper by Gale (1995) has followed Shleifer’s (1986) observation that firms want to coordinate the timing of investment he analyses it within a dynamic coordination game model, concluding that private and social benefits fail to coincide, particularly when the number of players is large.¹⁵

There are some analytical similarities between the present paper’s analysis of the issue of low investment stalemates and Leibenstein and Maital’s 1994 study of the causes of organisational X-inefficiency. These similarities are quite remarkable given the very different areas of application and the fact that their births were utterly independent.¹⁶ Both papers start with a game theoretic structure which is then converted to a model where the notion of critical mass plays a key role.¹⁷ The papers also share an approach to policy prescription which takes advantage of the particular nature of unstable equilibria.

In summary, and in more mundane terms, the central proposition of this paper is that an extreme conceptualisation of laissez-faire fails to come to grip with a very important function of public policy - as a coordinating agent. By insisting on a

¹⁴ Shleifer’s proposition is that “When expectations are *autonomous*, the economy can end up in any of several perfect-foresight stationary equilibria. These are Pareto ranked, so the economy can settle into a very bad equilibrium.” (Shleifer 1986: 1165) [emphasis added]. Earlier (on p. 1164) these expectations are described as synonymous with ‘business confidence’.

¹⁵ Specifically, whereas delay can enhance individual profit ‘... but they will all be better off if they invested immediately’ (Gale 1995: 2). Thanks are due to Bill Schworm for drawing my attention to Shleifer’s and Gale’s papers.

¹⁶ The existence of this study, I must confess, was brought to my attention in a phone conversation with Shlomo Maital, when the formal analysis of this paper was at its very final stage.

¹⁷ This despite two major differences between the two papers: (i) the structures of the games are different - Leibenstein and Maital (1994) use the prisoner’s dilemma strategy conflict, whereas no such conflict is present in the present paper’s game structure; (ii) the present paper draws its inspiration from Scheffing’s (1972, 1978, 1980) work and network externalities in Paul David’s (1985, 1980) and Brian Arthur’s (1984, 1990) path-dependence analysis, neither of which feature in the Leibenstein and Maital paper.

minimalist presence of public policy, ‘purist’ notions of laissez-faire not only deny that coordination mechanisms are vital to the pursuit of social justice goals, but they also assume away the pervasive presence of interdependent conduct in the economic domain. Where individual conduct closely depends on what others do, successful coordination will often require a significant measure of public policy.

3. Atomistic conduct - impeccable coordination or a long wait for Godot?

An observer of an economy in sustained recession, who knows that funds are available and that there are areas in which business could fruitfully invest, and who recognises that a dearth of investment is a major cause of recession, may well ask “what are they waiting for?” If we pin our hopes on the coordination of purely atomistic exchange, may we not find ourselves waiting for Godot?

Low levels of investment which persist over extended periods can be attributed to two fundamentally different sets of causes. On the one hand, the standard account traces poor levels of investment, and consequent low levels of economic activity, to ‘wrong’ prices. On the other hand, a number of alternative approaches have focused on structural features which block employment recovery, regarding relative prices as either fundamentally irrelevant or as potentially important, but rarely, if ever, the binding constraints which sustain high unemployment levels.

The first approach is shared by both the new-classical models, where the key role is played by prices which are wrongly perceived due to inability to distinguish

between relative and absolute price changes, and mainstream Keynesian models, where the key role is played by price rigidity or non-rational expectations. True, new-Keynesian analysis, such as the *efficiency wage* model, has made the standard approach more problematic by endogenising price rigidity, leading to the conclusion that even if individuals can perfect their perceptions of the price structure, and are given free rein to attend to their own objective functions, markets will not necessarily clear. Nevertheless, ‘wrong’ prices remain the root cause. This, for instance, is suggested by the fact that the efficiency wage approach proposes that if only workers and employers were not bound by gift-exchange norms (Akerlof 1984), or if workers were devout followers of the Protestant ethic (Shapiro & Stiglitz’s 1984 shirking model), or if wages could be set individually according to the individual’s marginal product (Stiglitz’s 1987 quality uncertainty/adverse selection model), then the spell of recession could at least be broken, if not entirely avoided.

What might explain this gravitation towards a malfunctioning price mechanism as the root cause of poor macroeconomic performance? It most probably reflects a latent belief in the potential of the Marshallian price-flex adjustment mechanism (Hicks 1977: xii) to shelter the economy against the affliction of low-level equilibria. Two implicit propositions are embedded in this Marshallian promise. The first posits that agents will dutifully move resources to and fro in response to price changes, regardless of their magnitude and whether they are lasting or merely transient. The second posits that if agents follow price changes in this way, the economy will readily move from one full employment equilibrium to another. The first proposition is quite absurd when the purchase of capital equipment and hiring workers involves the firm in building up stocks which turn into sunk costs on the

following day. Bearing in mind that any investment activity involves a long term commitment, the astute agent will avert their gaze away from the foreground towards the more remote horizon, where longer term prices reside. Those price changes which belong merely to the Marshallian ‘market’ and ‘short run’ periods will tend to be ignored as irrelevant.¹⁸

However, long term prospects, including relative price levels and general market conditions, may be favourable for investment which expands productive capacity (with short term prices being seen as either ‘right’ or of little relevance), and yet investment plans may be postponed indefinitely because the *time*, not the price structure, is wrong. The resulting delay may be of any duration. It is most likely that the stumbling block is neither prices nor a dearth of capital, but the limitations of purely atomistic conduct.¹⁹

To get a feeling for the limitations of purely atomistic conduct, let us take a detour to see what insights we can gain from a basic game-theoretic model. Imagine a non-cooperative (pure coordination) game with the following payoff matrix. For the moment, we will focus on the simple case of two players.

		B	
		WAIT	GO
A	WAIT	1,1	1,-5
	GO	-5,1	10,10

Figure 3.1

¹⁸ Unless, of course, they lead to a reconfiguration of the long run picture itself, but this is not what the Marshallian distinction between the market, short run and long run asks us to consider.

¹⁹ Unlike the conclusion drawn in Shleifer, where the focus is on the implementation of innovations, the result of the interdependence between firms regarding the timing of decisions is not confined to creating a variety of cyclical patterns, with total investment in the long run being unaffected. In the present paper, the stalemate is indefinite if the economy is confined to a laissez-faire regime, only a favourable random shock can relieve it from such predicament.

The payoffs for each player vary with the strategy chosen by the other. If the level of economic activity in the economy is in low ebb, and no-one invests, the payoffs are positive but small (1,1). If both invest at the same time, their payoffs are larger because of the favourable demand conditions that they generate for each other (10,10). Going it alone, however, is likely to saddle the investor with large sunk costs. In the absence of demand expansion, the result is excess capacity and/or pricing below average total cost and the sorry investor finds themselves between the devil and the deep blue sea. The payoff for going it alone is negative (-5), whereas the one who played it safe is doing better (1). This model is intended to capture the fact that, when demand externalities (or 'spillover effects') are substantial, individual decisions are crucially interdependent. What it shows is that, as a result of this interdependence, we have *two* Nash equilibria in pure strategy (1,1) and (10,10), and one in mixed strategies.²⁰

The problem faced by an agent in a real world setting is more complex, involving the behaviour of not just one other agent, but a whole population. The description offered by the two-player game is simply a metaphor for the markedly different situation where an individual agent's payoff for a given strategy depends on what a multitude of other members of the population do. A narrow translation of the two-player game to a multi-player situation suggests an extreme form of interdependence where either everybody waits or everybody goes. Typically, when

²⁰ Recall that in a mixed strategy player A relies on her assessment of the probability q ($0 < q < 1$) with which player B chooses the option Go. Repeating this argument symmetrically for player B (where B believes that A chooses Go with probability r), the mixed strategy is a Nash equilibrium provided q and r are chosen such that they leave each of the opponents indifferent between waiting (W) and investing (G), and in our case, if the numerical values in the payoff matrix above are $q = r = 2/5$. To find this value, q and r satisfy the condition that the expected value of the payoff for waiting is same as that for going, i.e., $(1 - q) + 1 \cdot q = -5 \cdot (1 - q) + 10 \cdot q$. This solves to give $q = 2/5$, etc'.

strategies are interdependent, choice will depend not on what everybody else does, but primarily on what a critical mass of the population does, with the precise value of this critical mass varying from case to case.

If the choice of a course of action ('strategy') depends on the presence of a critical mass, an individual examining the possibility of switching (*crossing over* in Schelling's terminology) between two strategies will stay put (Wait) as long as the proportion of the population which adopts the alternative strategy remains below this critical mass. Once the critical mass has crossed the threshold level, the individual will switch (Go). At the critical mass itself, they are poised on the balance between the two options - if they switch they will just break even. Hence, at this point they will be indifferent between the two options. The critical mass, in other words, represents an 'indifference' equilibrium point. This indifference equilibrium, is of course unstable because, by definition, it represents a switching point between two polar strategies - a small departure from the critical proportion will tilt the scale in favour of one of the two pure strategies.

At this point, intuition may benefit from a diagrammatic analysis along the lines of Schelling's analysis of behaviour patterns which depend on what a critical mass of the (relevant) population do. So let us map the scenario sketched in the two-player payoff matrix described in Figure 2.1 into a continuous payoff story, where the level of the payoff received by the individual firm varies with the proportion of firms which invest in the population at large. This is described in Figure 2.2 below.

To keep things simple, we assume a lumpy (non-divisible) investment project where

$$I = \begin{cases} I_0 & \text{if } P \geq P^* \\ 0 & \text{otherwise} \end{cases}$$

where

I = investment,

P = proportion of firms which are investing and

P^* = the requisite critical mass.

As Figure 2.2 below shows, we have two conditional payoff functions. If the firm chooses to wait, it believes that it will receive a fixed payoff of 1, regardless of whether other firms are investing. We can think of this payoff as the return on a small,

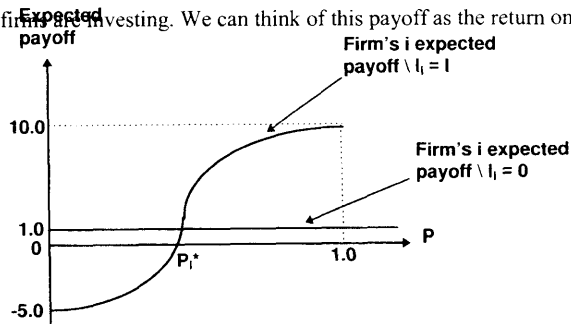


Figure 3.2

but fully utilised, productive capacity.²¹ If, alternatively, the firm undertakes the investment project, the level of its payoff, so the firm believes, depends crucially on what other firms do. It is worth taking on provided it is not going it alone, that is provided that a large enough proportion of firms ($\geq P^*$) have deemed the time proper for investing. Without any loss of generality, we can describe this in terms of a continuous pay-off variable whose value varies with the proportion of firms which are

investing, describing P^* as the critical mass at which the firm reckons that it will break even. When all firms invest, the payoff reaches its maximum - 10. However, if the other firms do not invest, the single firm that goes it alone ends up being saddled with the sunk cost of 5.0, and hence a payoff of -5.0.

Employing Schelling's (1978) terminology, we can now ask what would be the *macrobehaviour* of a system in which the behaviour of its economic agents is driven by the pattern of *micromotives* described above. The macrobehaviour depends on the distribution of the critical masses (threshold levels) of the individual firms. As Schelling (1972, 1978: 102-110) has shown, the number of possible equilibria in a situation characterised by this kind of interdependence among individuals, and their stability properties, hinges on the nature of the intersection between the cumulative density function (c.d.f.) of the critical mass (where both the domain and range of this function are bounded by 0 and 1) and the 45° line. Turning to the issue of the macro investment level, this suggests that an equilibrium with a positive number of investors exists only if the c.d.f. intersects the 45° line. Multiple equilibria are possible whenever the c.d.f. is curvilinear. These equilibria can lie anywhere between zero and one, depending on the distribution of the individual levels of requisite critical mass (P^*).

Although some of the equilibria will be unstable, multiple stable equilibria are a real possibility, and therefore an economy such that described above can find itself locked into a low level investment equilibrium. In contrast, unstable equilibria, if astutely confronted by public policy, can be a blessing, as we will see below. But alas, if they are not tenderly handled, they can be troublesome.

²¹ Without loss of generality, one can assume that the firms are all similar in terms of the spillover effects which they create.

The stability properties of an equilibrium point depend on the manner in which the c.d.f. intersects the 45° line. If the c.d.f. intersects the 45° line from above, the equilibrium will be stable (see Figures 2.3 and 2.4 below); otherwise it will be unstable.²² The reason for this is fairly straightforward. In Figures 2.3 and 2.4 below,

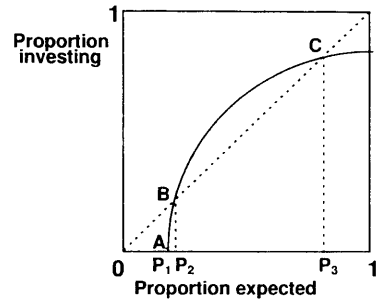


Figure 3.3

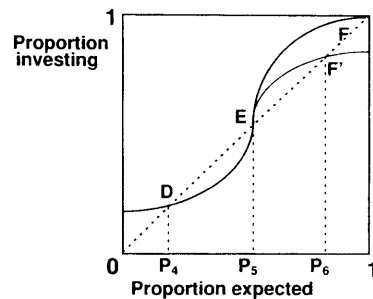


Figure 3.4

the solid line describes the c.d.f., showing the minimum proportion of investors required ('expected' in Schelling's terminology) for a given proportion of firms to undertake investment. For instance, point **A** shows that no firm will consider undertaking an investment project unless the proportion of other firms which are investing exceed P_1 . However, investment is not sustainable unless the proportion of investors is at least P_2 , because at no level below P_2 is the number of investors large enough to provide the requisite critical mass. At this point, everybody is waiting for everybody else to move first. It is only at the point **B** that the critical mass (P_2) generates a number of investors which is just large enough (P_2 maps into itself) to

²² Note that the c.d.f. will be monotonic when there are no negative spillover effects. Since Keynesian multiplier effects are the subject of the present paper, the focus is on positive demand spillover effects. There are, however, other types of interdependences, some of which are negative as in the race to get the licence for pay TV.

satisfy the condition $P = P_2$.²³ Point **A**, therefore, is a stable zero investment equilibrium.

To break the no-investment deadlock, a proportion P_2 of firms will need to move in unison - point **B** cannot be reached from the stable equilibrium at point **A** without a measure of coordination.

Point **B** has some attractive qualities, precisely because of it is unstable. If coordination, of one form or another, can successfully raise the level of investment activity to $P_2 + \epsilon$ (where ϵ is a small positive number), then from that point on the economy has the momentum needed to reach its highest investment level without any active coordination of individual investments being required. This is so because the instability of **B** means that at $P_2 + \epsilon$ the economy is catapulted into a cumulative dynamic process of autonomous (as opposed to coordinated) individual responses which can lead the economy to its highest feasible investment level - point **C**. This equilibrium, once reached, also has the desirable property that it is stable.

On Nash mixed strategy equilibria and dependence on the behaviour of a critical mass

There is a logical equivalence relationship between the concept of the critical mass is required to induce a switch between two strategies, and the concept of a *mixed strategy equilibrium* in game theory which will be briefly explored in this section. Let us return for the moment to the two-player case in Figure 2.1 above. As noted earlier, this game has three Nash equilibria: two in pure strategy and one in mixed strategy.

²³ At $P_2 + \epsilon$ and up to P_3 the response exceeds the required minimum.

Without loss of generality, the normal form of the game presented in Figure 1.0 is modified to that described by Figure 2.5 below:

		B	
		WAIT	GO
A	WAIT	0,0	0,-5
	GO	-5,0	10,10

Figure 3.5

Again we have three Nash equilibria - two in pure strategy [(0,0),(10,10)], and a mixed strategy with $q = p = 1/3$. Extending this to N person game, the mixed strategy equilibrium simply suggests that when N is very large, we can have an equilibrium level of investment where 1/3 of the firms are investing, provided all agents use a randomising rule where $q = 1/3$.

Mapping the normal form of the game in Figure 2.5 into a graph which gives the extended form of the game, we can have one of the two alternative scenarios described in Figures 2.6 and 2.7 below. Figure 2.6 adheres to the case of discrete, binary payoffs, whereas Figure 2.7 presents a special case of continuous payoffs, where they are linearly dependent on the proportion of firms investing, P .

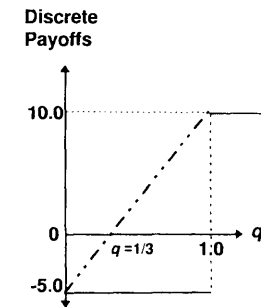


Figure 3.6

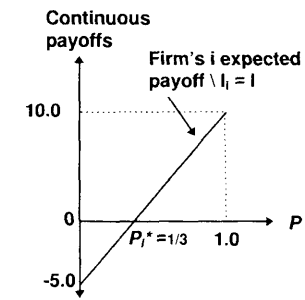


Figure 3.7

Figure 2.6 illustrates the fact that, given the payoffs structure described in Figure 2.5, and treating these payoffs as strictly discrete, the probability of playing Go in a Nash mixed strategy equilibrium is 1/3.²⁴ If we have a large number of players, each with only two discrete payoffs, and if all follow rule 'Go with probability 1/3 and Wait with 2/3', then aggregate investment is in equilibrium, with one third of the firms investing.

Figure 2.7, in contrast, deals with a very special case of continuous payoffs, showing that the notion of Nash mixed strategy equilibrium can be given a different interpretation, provided a number of conditions are satisfied: (i) the payoffs are continuous, (ii) the payoffs (Y) are linear in the proportion (P) of the firms which are investing, where $Y \in [-5, 10]$ and $P \in [0, 1]$, and finally (iii) all players have identical continuous payoff ($Y_i = \alpha_i P$, $\alpha_i = \alpha$ for all i). In this case, we have an equilibrium at which the one third of the firms which are investing are just breaking even, and,

²⁴ This is because the expected value for going is given by the linear combination of -5 (payoff for going when the other player is waiting) and 10 (payoff when both are going). Given that the expected payoff for waiting is uniformly zero, the probability of going must yield an expected value of zero. This means that the probability of playing go is such that the linear combination of -5 and 10 is zero; this yields $q = 1/3$. This, by definition, is the Nash equilibrium probability.

therefore, as the concept of the Nash equilibrium mixed strategy requires, each firm is poised at the limit point of indifference between investing and waiting.

Game theorists have been rather uneasy with the proposition that real world agents simply randomise their strategies. Rather, they have been more inclined to follow Harsanyi's (1973)²⁵ proposition, seeing q as a measure of the uncertainty a player has as to whether the other player is investing (in a two person game). In an N person game, q is then treated as an estimate of a proportion of N players who are opting for the particular pure strategy (eg., Gibbons 1992:30; Tirole 1991:230). This latter interpretation suggests that the value of q in a Nash mixed strategy equilibrium can be interpreted as the measure of the critical mass of investors which allows the investing firms to just break even. (The magnitude of this proportion can even be treated as a known number, with no uncertainty being attached to it.)

Figures 2.6 and 2.7 readily map into an identical Schelling diagram, as illustrated in Figure 2.8. That is, Figure 2.8 applies to a large population of firms with either two discrete, or continuous, payoffs, will all players having identical payoff functions.

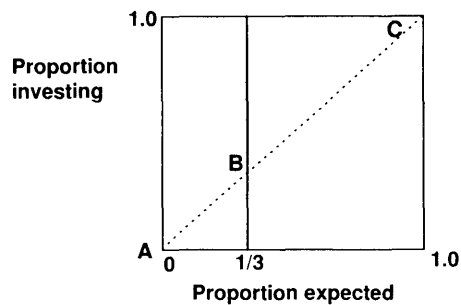


Figure 3.8

²⁵ As reported in Gibbons (1992:30) and Tirole (1991:230).

We have three equilibria - **A** and **C**, which correspond to the pair of equilibria in pure strategy [(0,0);(10,10)], and **B**, which corresponds to the mixed strategy in the two-person game. We readily know that **B** is not a stable equilibrium. Indeed, this highlights the fact that a Nash mixed strategy equilibrium is unstable by its very construction.²⁶ That is, returning to two-person game, we know that if player B believes that A will invest with probability $q - \epsilon$, she will opt for the pure strategy of waiting (W) (rather than choosing to mix strategies), while if this probability is believed to be $q + \epsilon$, she will choose the pure strategy of going (G).

This analogy between the game theoretic notion of a Nash mixed strategy equilibrium and Schelling's depiction of the link between micromotives and the macrobehaviour draws our attention the crucial role played by the *heterogeneity* of the population. The population depicted in figure 8.0 is homogenous with respects to the threshold level that induces a cross-over between the two pure strategies.²⁷ The result is a very fragile macroeconomy where an exogenous shock which creates a jolt large enough to push the economy away from **C** to a notch to the left of **B** will send it reeling to **A**, where the investment level is zero. On the other hand, we know that populations which are heterogenous with respect to **P** can have multiple equilibria, with a roughly even mixture of stable and unstable equilibria. The protective properties of such diversity of structure are self-evident.

This analysis has a practical upshot: it is extremely important to explore the nature of diversity in a particular population, since the structural property of the

²⁶ There is affinity between the instability of this particular mixed strategy and the mixed structure discussed by Maynard Smith (1982) for dynamic non-cooperative games which share the structure of the payoff matrix in Figures 2.1 and 2.5, where the individual, in Smith's terms, is 'playing the field'.

²⁷ The c.d.f. is a straight vertical line, because the density of the p.d.f. is wholly centred on P^* .

macroeconomy crucially depends on the configuration of this diversity. Analytically, this means that parameters such as the moments of probability distribution functions play a critical role in determining the array of possible (typically multiple) equilibria and the stability properties of these equilibria.²⁸

4. *Contemplating the agenda for public policy*

This analysis yields some obvious policy propositions. For a stagnant economy with a pattern of micromotives of behaviour of the type represented by Figure 3.1, the role of public policy is to create the momentum which can take the economy to **B** (and a notch beyond). This point represents a self-sustained take-off state - once there atomistic conduct alone will take it to an even higher level of investment at point **C**. Similarly, for the type of economy with a pattern of micromotives represented by Figure 2.4, the challenge to public policy is to take an economy which is locked at **D** under an unfettered laissez faire regime²⁹, to just beyond **E**.³⁰ Atomistic conduct then will have the potential to carry the macroeconomy to the safety of **F** (or **F'**, depending on the c.d.f. describing the pattern of micromotives).

²⁸ See Gill (1984) for yet another example where the structure of the diversity plays an important role.

²⁹ In Figure 2.4, we have yet another example of two stable equilibria - points **D** and **F** (or **F'**). The proportion of investors is positive in both cases, and we, therefore, can have either a low (P_3) or high (P_5 or P_6 ; $P_6 = 1$) investment equilibria.

³⁰ The proportion of investors is positive at **D**, thanks to a group of firms whose investment is independent of what other firms do.

Different configurations of micromotives may have markedly different policy implications. In this paper, individuals cross over from a no (yes) to yes (no) operational mode when they believe that a critical mass of the population has adopted the yes (no) mode. What determines this value? The standard economist will opt for a description of a well-defined payoff function, where the value of the threshold is determined by the point of equality between the expected values of the alternative operational modes - an 'indifference' point. Yet psychological factors are likely to play a important role, not only when the decision involves a cross over in personal stance on a specific social issue (eg., banning nuclear arms, granting gay rights or admitting women to the priesthood), but also in corporate choices such as a managers' decision on whether to switch from an established technology to a promising, but not terribly well tested, new technology.

This in turn suggests that P^* does not necessarily reflect the outcome of a meticulous pecuniary cost/revenue analysis. Rather, it may be a rule of thumb, or a psychological parameter (which varies from one firm to another) which simply asserts, 'the trouble is not worth it unless enough people believe that the time is indeed right'. Although such a belief may depend on a rough calculus of the impact of demand externalities on profit levels, it may alternatively be underpinned by something entirely different - interdependence of expectation formation per se - 'when in doubt about your own assessment of the situation, look over your shoulder, and see whether a large enough number of *others* share your assessment of the situation'. At the most fundamental level, it is an anxiety about going it alone.

If such psychological factors play a prominent role, the moments of the probability density function (p.d.f.) of individuals' critical masses are more likely to

reflect the variety of human nature, rather than the spread of meticulously objectively 'calculated' values of expected profit rates. If the variance of human nature significantly exceeds the variance of the objective opportunities underpinning the payoffs, then both explanation and prediction hinge on the socio-psychological element. (I do not feel that the fact that the notion of risk aversion harboured by a von-Neuman/Morgenstern concave utility function provides enough elbow space for an adequate understanding of the psychological input into the choice problem.)³¹

Therefore, policy measures which may be very effective in a world driven by shrewd assessments of the delicate balance of profit and loss may prove much less potent in a situation where agents are primarily concerned with ensuring that they do not do what others are not doing. The architects of recovery strategies may need to go beyond the texts of economic science for inspiration.

Let me set aside, for the moment, the scenario where non-pecuniary considerations are dominant, and turn to the case where a modest (and politically feasible) cut in the rate of interest will have a discernible impact on the value of P^* for each of the individual firms. Does this alter the core conclusions of the present analysis? The answer is not really. In terms of our analysis, this means an interest cut would lead to a leftward shift of the density in our original p.d.f. This measure will rescue the economy only if the moments of the p.d.f. are modified radically enough to allow the cumulative density function (c.d.f.) to lie wholly above the 45° line. The cuts in rates of interest which are within the realms of economic and political feasibility are likely to have a more modest impact on the p.d.f. In this case, interest cuts will generate new points of intersection between the c.d.f. and the 45° line. If so,

³¹ So, those threshold levels exist as the cross-over points between two pure strategies.

the need for coordination measures which can lead the economy to the best take-off point remains.

Finally, it is worth noting that increase of effective demand does not guarantee a break away from a low investment deadlock. Effective demand is designed to address the problem faced by the Western economy in the early '30s when it was riddled with very low levels of capacity utilisation across the board. In cases like this, increases in effective demand can indeed guarantee a rise in the rate of capacity utilisation. However, to successfully convince a large enough proportion of firms that a large enough number of firms is intending to invest in the immediate future may need something much stronger than a boost in consumer expenditure. The policy will need to be *qualitatively*, not just quantitatively, different.

5. A Delicate Economic Balance

Points like **B** and **E** in Figures 2.3 and 2.4 represent a very delicate economic balance. Thus far, I have emphasised the desirable aspects of these unstable equilibria. However, we do know that the source of the blessing is also the source of a curse - a small perturbation to the left of these points will send an economy reeling into a trap of low level macro-equilibrium. Human communities are well aware of the dynamic properties of such delicate balances, in both the economic and broader social domains. The business community is well aware of the mutual interdependence of economic fortunes of its corporate members and the critical role played by the notion of 'business confidence', vague as it may be. However, a correct diagnosis of the disease,

and even a recognition of the limits to atomistic conduct, do not of their own accord generate the necessary coordination. Coordination failures not only occur, they can also persist.³²

Yet, although all economies are afflicted by examples of coordination failure, some are less prone to reeling down the hill into a low level economic activity. Undoubtedly, some of these differences must be traced to differences in economic endowment, the positional advantages they enjoy in the world economy and the phase of economic growth they happen to be in. But this is only part of the story, because societies also differ in their capacity to handle delicate economic balances and negotiate change. These are differences in their institutional frameworks, which include not only formal but also informal structures embedded in the social, political and business culture.

For instance, in a society where 'short-term' behaviour is rare, business enjoys a measure of security which allows them to ignore the short term, instead being guided solely by the long run prognosis, when they know that it is a widely shared perspective. In contrast, a firm operating, for instance, in an environment where in response to a downturn, the bulk of other businesses are downsizing their workforce substantially, will jeopardise its competitive position if it does not follow suit, since it would be carrying a disproportionately large burden of overhead costs. So it has no choice but to join in. Although this may take its toll profits in the long run level, insolvency because of very tight short term conditions is a real possibility in a world of imperfect capital markets.

³² See Leibenstein and Maital (1994) for such failures within communities as small as those involved in individual business enterprises.

The following historical tale may be helpful here. In 1982 the Australian airline Qantas jeopardised the precious reputation it had earned, thanks to its excellent safety record, sharply reducing its long standing apprenticeship program in a bid to cut costs during a cyclical macroeconomic downturn. Not long after, Qantas was taken by surprise when it was forced to farm out a sizeable portion of its maintenance to overseas companies. An international economic consultant who heard this story some years ago briefly commented: 'the Germans would have done this; they would have kept their training program intact'. National traditions create conventions which, as game theorists have emphasised for some time now, can generate the coordination required to keep the risk of being jolted to the wrong side of an unstable equilibrium (such as **B**, in Figures 2.3 and 2.8 and **E** in 2.4) at bay.

Cultural traditions and social conventions cannot, of course, be picked up from the shelf of the supermarket of ideas because they are historical evolutions, the product of particular economic and political circumstances in the past and of the social ethos of a given community. Nevertheless, due analytical attention should be paid to social institutions, whether formal or informal, which by their very nature provide a measure of coordination in matters economic, for two main reasons.³³ The first, and most crucial, is the fact that such institutions can easily be destroyed if taken for granted (or worse still is treated as inimical to the 'market'). Once destroyed they may be irretrievable. Secondly, by obtaining analytical insights into the dynamic properties of the range of socio-economic conduct found in different industrially

³³ Here again, Thomas Schelling alerted us to this issue and to the idea of the 'social contract' as a coordination device which governs the behaviour of large communities as early as 1960 (Schelling 1980: 92); the cited date refers to the second edition of the book.

developed countries, we may achieve a better analytical understanding of the dynamics of putative laissez-faire regimes.

6. Conclusion

This paper analyses an unfortunate consequence of the narrow focus of the standard approach on the notion of 'correct' prices and on solipsistic agents who operate outside any social context. The result is a tendency to identify 'wrong' prices as the universal cause of economic malaise, and laissez-faire as the panacea.

Prices can, of course, operate as binding constraints, but there are important circumstances where the cause of the failure of a system to realise its potential lies entirely in another domain. Organisations, even small ones, can be locked into inferior equilibria simply because of their inability to coordinate the action of their component parts. Turning to the macroeconomy, there are circumstances where better states are within reach, as far as the price structure is concerned, but the system fails to generate a dynamic adjustment path which can take it to these. The theoretical focus on comparative statics has tended to draw attention away from the question of dynamics, obscuring the possibility that the binding constraint in a given situation is the lack of a process which is capable of facilitating transition from one equilibrium to another. Coordination failure, therefore, may have little to do with a failure to eliminate price rigidity; it may, instead, reflect a weakness in the system's ability to generate the momentum required for change.

The specific concern in this paper is with the prospects for investment recovery in an economy which is in the throes of recession, with low investment and high unemployment persisting over time. The principal proposition is that interdependence of decisions is a vital aspect of the dynamics of macroeconomic adjustment which can explain a failure to break out of an impasse.

The paper employs a simple two-person coordination game to describe a particular type of coordination failure - a case where everybody is waiting for everybody else to invest first. It then transforms the description to a game with a continuum of players with continuous payoff, where an individual firm's decision on whether or not to invest depends not on everybody else investing first, but on the behaviour of a critical mass of firms. If the proportion of firms who invest reaches this critical mass, it invests, otherwise it leaves the level of its productive capacity intact. Drawing on Schelling's analysis of interdependent behaviour, the analysis shows that multiple (stable) equilibria are possible whenever firms are averse to 'going it alone'. As the paper argues, this situation will certainly arise when demand spillover effects are significant. In addition, investment projects tend to be lumpy because of limited scope for divisibility. The fundamental issue, in this case, is not one of having an adequate *level* of effective demand *per se*, but rather of it having a particular *quality*. When an economy is saddled with low investment levels, effective demand will perform its 'Keynesian' role only if it successfully operates as a signalling mechanism, convincing a sufficient number of individual agents that a critical mass of agents is set to take on substantial investment projects. If it achieves this, the increase in the level of effective demand will break the impasse, and in game theoretic terms,

the policy can be described as providing the mechanism necessary to attain an optimal solution in a *coordination/assurance game*.

Although the paper describes standard, fairly narrowly defined, economic reasons which can give rise to an interdependence of decisions which then locks the economy into a recession, it also emphasises the importance of analysing the phenomenon of interdependence within the broader social context, seeing it as a socio-psychological and cultural phenomenon as much as a purely economic one. It is even possible that the interdependence we are addressing is fundamentally a socio-psychological and cultural phenomenon.

When a number of equilibrium levels of investment are feasible, some will be unstable. Unstable equilibria have two faces - if astutely exploited, they can offer the key to recovery, but if left to their own devices, they can show an ugly face. This instability, the paper has argued, endows public policy with a useful potential. An unstable equilibrium can serve as a take-off point for growth, provided coordinating measures can lift investment to a level which is just a notch beyond the unstable equilibrium. Once there, atomistic conduct alone can lead the economy to an even higher equilibrium level. The role for public policy, therefore, is to build the momentum required for the 'early part of the journey'.

The unappealing face of unstable equilibria is their ability to intensify the impact of an external shock, which jolts an economy from a high-level stable equilibrium to just below a lower-level unstable equilibrium, sending the economy downhill to a lower-level stable equilibrium.

Although all economies are afflicted by examples of coordination failure, some are less prone to reeling down the hill into a low level of economic activity. The

paper suggests that societies differ in their capacity to handle delicate economic balances and negotiate change, reflecting differences in their institutional frameworks. These differences include not only formal but also informal structures embedded in the social, political and business culture. Essentially, such societies are endowed with operational conventions which perform like coordination-reassurance mechanisms to indicate that the requisite critical mass will be sustained. For instance, shared notions of 'social responsibility' can prevent a massive retrenchment of workers when an economy goes off the boil and maintenance of safety standards in the face of financial tightness. Similarly, ethical conduct can withstand extreme provocation in a society which is confident that its ethical norms are widely shared. In contrast, societies which are dominated by a strong individualist ethos, and those turning away from social institutions in need of repair in a rush to let market forces 'free', increase their chances of periodically experiencing socially destructive bouts of severe macroeconomic deterioration. Such societies also run the risk of progressively depleting their precious nonrenewable resource of cooperative social conduct.

In a more fundamental sense, these propositions apply not just to macroeconomic policy, but to a whole gamut of social and economic policies, where a switch in the behaviour of individuals from one mode to another depends crucially on the behaviour of a critical mass. Public policies and non-government organisations can often be justified simply in their capacity to reassure individual members of the community that they are not out on a limb on their own.

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