

3 Structural crises of adjustment, business cycles and investment behaviour

Christopher Freeman

Science Policy Research Unit, University of Sussex, Brighton and MERIT, State University of Limburg, Maastricht

Carlota Perez

UNIDO-Ministry of Industry, Caracas and Science Policy Research Unit, University of Sussex, Brighton.

Introduction

This chapter discusses the revival of interest in long-term fluctuations in the growth of the world economy and particularly in the Schumpeterian theory of business cycles. After reviewing the common ground in relation to investment behaviour and business cycles, it goes on to discuss the failure of Keynesian economics to come to terms with the influence of technical change. The central theme of the chapter is that certain types of technical change—defined as changes in ‘techno-economic paradigm’—have such widespread consequences for all sectors of the economy that their diffusion is accompanied by a major structural crisis of adjustment, in which social and institutional changes are necessary to bring about a better ‘match’ between the new technology and the system of social management of the economy—or ‘regime of regulation’. Once, however, such a good match is achieved a relatively stable pattern of long-term investment behaviour can emerge for two or three decades. This point is illustrated with respect to the rise of information technology. It is argued that this pervasive technology is likely to heighten still further the instability of the system before a new, more stable pattern of growth is attained.

The resurgence of interest in Schumpeter’s ideas (e.g. Elliott, 1985) is associated with the slow-down in the growth of the world economy in the last decade. Whereas during the prolonged post-war boom of the 1950s and the 1960s there was some tendency to assume that the general adoption of Keynesian policies would prevent the recurrence of any depression comparable to that of the 1930s and would smooth out smaller fluctuations, this confidence was somewhat undermined by the deeper recessions of the 1970s and 1980s and the return of much higher levels of unemployment. Not surprisingly, this has led to renewed interest in long-cycle or long-wave theories, which make analogies between the 1930s and the 1980s. This chapter concentrates on the explanation of these deeper structural crises of adjustment, without making any assumptions about fixed periodicity or statistical regularity.

We start by looking at the common ground in the analysis of business cycles. We shall quote extensively from Samuelson for several reasons. First of all, he is probably the most authoritative neo-Keynesian economist, and one who commands respect throughout the profession. Secondly, business cycles have always been one of his central professional interests. Thirdly, as the author of the most widely read economics textbook in the Western World, he provides in the successive editions of this book a convenient synthesis of the changing state of the art (Samuelson and Nordhaus in the most recent and thorough revisions, i.e. the 12th edition).

Areas of agreement in business cycle theory

There are of course many different explanations of business cycles and many explanations for the exceptional severity of the 1930s depression and of the recessions of the 1970s and 1980s. But, as Samuelson has pointed out and most textbooks on the business cycle confirm, there is actually a measure of agreement on *some* of the central issues.

Most importantly there is virtually universal agreement that one of the main sources of cyclical fluctuations in the economy is the instability of investment. All empirical studies of business cycles show much greater fluctuations in the capital goods industries than in consumer products, as in the extreme example of the Great Depression of the 1930s, when GNP fell by 30 per cent in the United States but output of producers’ durable equipment fell by 75 per cent.

Samuelson (1980) comments:

Ordinarily, consumption movements seem the *effect* rather than the *cause* of the business cycle. In contrast, there is reason to believe that the movements of *durable* goods represent key causes in a more fundamental sense. [p. 242]

The wording is slightly changed in the 1985 edition but the emphasis on investment remains and indeed virtually all schools of economic theory would accept the empirical evidence on the relative amplitude of fluctuations in different sectors of the economy. Moreover, they would also agree that there are certain aspects of investment in plant and equipment which make some fluctuations almost inevitable: ‘postponability’ on the one hand and competitive pressures to expand capacity on the other; the uneven development in the relative growth rate and capital intensity of various sectors of the economy; indivisibilities in many large investments (‘lumpiness’) and the ‘accelerator’ principle tending to amplify investment in upswings and diminish it in downswings. On a smaller scale some similar considerations apply to inventories and to consumer durables. These ‘endogenous’ factors are in themselves sufficient to account for fluctuations in the system.

However, Samuelson (1980) points out in his ‘synthesis’ that ‘external’

factors also play an important part:

Most economists today believe in a combination of external and internal theories. To explain major cycles, they place crucial emphasis on fluctuations in *investment* or *capital* goods. Primary causes of these capricious and volatile investment fluctuations are found in such external factors as (1) technological innovation, (2) dynamic growth of population and of territory, and even in some economists' view, (3) fluctuations in business confidence and 'animal spirits'.

With these external factors we must combine the internal factors that cause any initial change in investment to be *amplified* in a cumulative multiplied fashion—as people who are given work in the capital goods industries respond part of their new income on consumption goods, and as an air of optimism begins to pervade the business community, causing firms to go to the banks and the securities market for new credit accommodation.

Also, it is necessary to point out that the general business situation definitely reacts in turn on investment. If high consumption sales make business owners optimistic, they are more likely to embark upon venturesome investment programmes. Inventions or scientific discoveries may occur independently of the business cycle, but their appreciable economic introduction will most certainly depend on business conditions.

Therefore especially in the short run, investment is in part an *effect* as well as a cause of income movements. [p. 246]

As Samuelson points out, essentially similar logic applies, of course, in the reverse direction leading to the danger of a cumulative downward spiral. Temporary over-capacity as a result of bunching of investment, perceived lack of sufficient new markets, the saturation of some existing markets, major instabilities in the international economy, over-restrictive monetary policies, uncertainties about technology, protectionism and general lack of business confidence are among the many influences which may trigger or accelerate a vicious circle of declining investment and national income. All of them have been identified as important influences in the severe depression of the 1930s.

Thus far, then, is an area of general agreement about the causes of business cycles and the problems of 'virtuous' and 'vicious' spirals in economic activity. However, a gulf still remains between those economists who, despite what has been said above, still look to the self-regulating private market mechanism, the rate of interest, capital-labour substitution, and monetary policy as the main stabilising forces governing investment behaviour and consequently the fluctuations in the system as a whole, and those who, like Keynes and Samuelson, lack faith in this mechanism to sustain long-term stable growth. The central issue is the possibility of rational optimising behaviour at the micro level of the firm. It will be argued in Part IV of this book that this model of entrepreneurial behaviour is fundamentally flawed. This means that periods of stable growth depend more on a general climate of confidence, including widespread belief in the future potential benefits from technical change, than on an unbelievable set of assumptions about perfect information and accurate calculations on

the future rate of return of a wide variety of investments with uncertain outcomes.

Keynes

It is often said that Keynes was deeply rooted in the neo-classical tradition of economics and this is no doubt true. Nevertheless, even in his earliest writings, it is possible to trace his awareness of these limitations of the self-regulating market mechanism. Moggridge (1976) points out that already in 1913 in his book on *Indian Currency and Finance* he insisted on '... the essential fragility of the economic order which others took to be natural and automatic and emphasized the need for conscious management'.

This already foreshadowed his more general onslaught on *laissez-faire* in the 1920s:

The world is *not* so governed from above that private and social interest always coincide. It is *not* so managed here below that in practice they coincide. It is *not* a correct deduction from the Principles of economics that enlightened self-interest generally *is* enlightened; more often individuals seeking separately to promote their ends are too ignorant or too weak to attain even these.

In 1934 in one of his broadcasts on the BBC, he was even more explicit (quoted in Eatwell, 1982):

On the one side are those who believe that the existing economic system is, in the long run, a self-adjusting mechanism, though with creaks and groans and jerks and interrupted by the time lags, outside interference and mistakes ... on the other side of the gulf are those who reject the idea that the existing economic system is, in any significant sense, self-adjusting ... The strength of the self-adjusting school depends on its having behind it almost the whole body of organised economic thinking and doctrine of the last hundred years. This is a formidable power ... For it lies behind the education and the habitual modes of thought, not only of economists, but of bankers and businessmen and civil servants and politicians of all parties ... thus if the heretics on the other side of the gulf are to demolish the forces of 19th century orthodoxy ... they must attack them in their citadel. No successful attack has yet been made ... I range myself with the heretics.

This broadcast foreshadowed the publication of his *General Theory of Employment, Interest and Money*, which at least temporarily was indeed a fairly successful attack (Keynes, 1936) on the 'citadel', and which argued that '... the duty of ordering the current volume of investment cannot safely be left in private hands' and advocated the 'socialisation of investment'. By this he meant, of course, not public ownership or socialism, but public responsibility for the overall level of investment and employment. He insisted that if private decisions to invest were inadequate to overcome a depression, then it was the responsibility of government to compensate for this deficiency. Interest rate policy probably would not be in itself a sufficient inducement to stimulate the necessary flow.

An inadequate level of private investment might arise from many causes; in a famous and often-quoted passage Keynes stressed the impossibility of purely rational calculations about the future rate of return from new investment and compared it with an expedition to the South Pole. He stressed the crucial importance of a climate of confidence and the role of 'animal spirits'. He pointed to the problem of excess capacity even in some industries which had grown rapidly in the previous boom and the problem of temporary saturation of particular markets. He stressed ironically the good fortune of Ancient Egypt in having pyramids and large-scale investment which did not 'stale with abundance' and of the Middle Ages in having cathedrals: 'Two pyramids, two Masses for the dead are twice as good as one, but not so two railways from London to York.'

From the time of the publication of the *General Theory*, orthodox economics mounted a counter-attack mainly on the issues of monetary policy, fiscal policy, and wage flexibility. However, there has been no comparable counter-attack on his theory of private investment behaviour. Indeed, Siegenthaler (1986), quoting Schackle's (1967) essay on 'Keynes' Ultimate Meaning', argues that this is Keynes' most lasting and fundamental contribution to economic theory.

According to Schackle:

Keynes' whole theory of unemployment is ultimately the simple statement that, rational expectation being unattainable, we substitute for it first one and then another kind of irrational expectation; and the shift from one arbitrary basis to another gives us from time to time a moment of truth, when our artificial confidence is for the time being dissolved, and we, as business men, are afraid to invest and so fail to provide enough demand to match our society's desire to produce.

Siegenthaler comments on this passage:

This interpretation of Keynes calls for interpretation itself, but at least three things are made very clear by Schackle. First, confidence enters the scene in a context in which rational expectations cannot be formed on the basis of adequate knowledge, so that confidence must be 'artificial'; subjective certainty which encourages an actor to invest is grounded not in a true model of economic reality, but in an arbitrary one for which sufficient evidence fails to be available; in very particular situations confidence gets dissolved and actors become aware of objective uncertainty, of their inability to know the future and it is only in those 'moments of truth' that subjective uncertainty governs the behaviour of the actor . . . Actors get confident not on the basis of adequate knowledge, not as a result of procedures leading to objectively superior forecasting methods, not as an outcome of individual optimising strategies of selecting and handling information . . . But they do get confident despite uncertainty . . . Confidence, albeit an artificial one, prevails except on rare occasions.

Solow (Klamer, 1984) has scornfully dismissed the attempt of the new school of 'rational expectations' to argue that actors, whether consumers, wage earners or entrepreneurs, can indeed form rational, long-term expectations about such future events as the impact of electronic tech-

nology on the economy. And indeed few would attempt to deny the force of Solow's argument or that of Keynes, with respect to major technical innovations.

Nevertheless, because of the crucial importance of technical change for investment behaviour, which is acknowledged by all schools of economic thought, it is essential to examine in more depth the question of the influence of technical change, on the state of confidence and vice versa. At certain times technical change appears to undermine confidence and stability, while at others it has the opposite effect. At the level of the individual innovative investment, the findings of empirical studies of investment and evaluation in R & D are clear-cut and virtually unanimous: they strongly support the view of Schackle and Schumpeter that investment in new products and processes has an element of true uncertainty: by definition the outcome cannot be known (Freeman, 1982, Chapter 7).

However, the analysis cannot be restricted to the level of the individual innovation or to counting innovations; the qualitative aspects and the systems interrelatedness of innovations must be taken into account. Under favourable conditions, the Schumpeterian bandwagons roll and business confidence improves, leading to an atmosphere of 'boom' in which, although there are still risks and uncertainties attached to all investment decisions, animal spirits rise. Such favourable conditions include complementarities between innovations and the emergence of an appropriate infrastructure as well as some degree of political stability and institutions which do not hinder too much the diffusion of new technologies. In these favourable circumstances the growth of new markets and the profitability of new investments appear to offer a fairly stable prospect of future growth, despite the uncertainties.

But there are also circumstances when technical change could have the opposite effect and could destabilise investment by undermining confidence in the future prospects for the growth of some firms, industries or economies. Moreover, as technologies and industries mature over a long period, diminishing returns and declining profitability may set in, leading to sluggish investment behaviour. If this is at all widespread it may take major social and political changes to restore confidence in the future growth of the system on the basis of new technologies. In the section on 'Diffusion of new techno-economic paradigms and institutional changes' we shall discuss the circumstances in which this can occur.

Here we wish only to make the point that in the early stages of radical technical innovation uncertainty prevails, so that Schumpeterian entrepreneurship and Keynesian animal spirits are necessary for the first steps. Once diffusion is under way, even though diffusion itself involves further innovation, the excitement generated by rapid growth of markets and/or exceptional profits of innovations may generate rising confidence and waves of imitation, provided the social and institutional framework and the infrastructure favour these developments.

Keynes himself once acknowledged the dominant influence of technical change on investment behaviour in his *Treatise on Money* (1930):

In the case of fixed capital, it is easy to understand why fluctuations should occur in the rate of investment. Entrepreneurs are induced to embark on the production of fixed capital or deterred from doing so by their expectations of the profit to be made. Apart from the many minor reasons why these should fluctuate in a changing world, Professor Schumpeter's explanation of the major movements may be unreservedly accepted . . .

It is only necessary to add to this that the pace at which the innovating entrepreneurs will be able to carry their projects into execution at a cost in interest which is not deterrent to them will depend on the degree of complaisance of those responsible for the banking system. Thus while the stimulus to a credit inflation comes from outside the banking system, it remains a monetary phenomenon in the sense that it only occurs if the monetary machine is allowed to respond to the stimulus. [Vol. 2, p. 86].

This passage is remarkable not only for its unequivocal acceptance of Schumpeter's explanation of the major surges of investment in capitalist societies but also its emphasis on the enabling role of monetary policy. It is all the more surprising that neither Keynes nor the Keynesians followed up this recognition of the crucial role of technical innovation. In fact, in the *General Theory* Keynes regressed to a position of neglect of technology when he introduced the largely artificial concept of a secular decline in the marginal efficiency of capital unrelated to the actual changes in techniques or in the capital stock. Schumpeter was therefore justified in one of the main points of his critique of the *General Theory*:

it limits applicability of this analysis to a few years at most — perhaps the duration of the '40 months cycle'—and in terms of phenomena, to the factors that *would* govern the greater or the smaller utilisation of an industrial apparatus *if* the latter remains unchanged. *All* the phenomena incident to the creation and change in this apparatus, that is to say the phenomena that dominate the capitalist process, are thus excluded from consideration. [1952, p. 282]

For the Keynesians it became a matter of relative indifference *which* were the new technologies and the fast-growing industries. We shall argue that it does matter very much *which* are the important new technological systems, because they are unique and their effects on private and public R & D and investment strategies, and the government policies, and institutional changes, which are required to advance them, may be very different. We shall argue that Keynesian analysis and policies were and are deficient with respect to long-term changes in technology, their effects on business confidence and structural change in the economy and the specifics of infrastructural investment. Almost all neo-Keynesian (and much other) macroeconomic analysis and modelling is restricted to purely *quantitative* aspects of investment and employment, whereas Schumpeter rightly insisted on the crucial importance of *qualitative* aspects.

Clearly, this criticism of Keynesian theory rests on a particular view of the relationship between technical change and business cycles which is usually associated with Schumpeter's long-wave theory. It sees the major booms, such as those of the 1950s and 1960s or the 1850s and 1860s as based on the diffusion of major new 'techno-economic paradigms' into the world economy and the deeper depressions as periods of structural adjustment, when the social and institutional framework is adapting to the rise of major new technologies.

Interestingly enough, even though Samuelson (1981) has dismissed the likelihood of another major depression, he did stress the probability of a prolonged downturn in the rate of economic growth:

It is my considered guess that the final quarter of the 20th century will fall far short of the third quarter in its achieved rate of economic progress. The dark horoscope of my old teacher Joseph Schumpeter may have particular relevance here.

Samuelson's reference to Schumpeter clearly implies that the major long-term fluctuations in economic development cannot be explained simply in terms of conventional short- and medium-term business-cycle theory but require an additional dimension of analysis. This involves the rise of new technologies, the rise and decline of entire industries, major infrastructural investments, changes in the international location of industry and technological leadership and other related structural changes, for example, in the skills and composition of the labour force and the management structure of enterprises.

A taxonomy of innovations

It has been argued that a weakness of most neo-classical and Keynesian theories of technical change and economic growth is that they fail to take account of the *specifics* of changing technology in each historical period.

One reason that economists do not attempt this daunting task is, of course, the sheer complexity of technical change. How can the thousands of inventions and innovations which are introduced every month and every year be reduced to some kind of pattern amenable to generalisation and analysis? In this section we shall suggest a taxonomy of innovation, based on empirical work at the Science Policy Research Unit. We shall distinguish between (1) Incremental innovation; (2) Radical innovation; (3) New technology systems; (4) Changes of techno-economic paradigms. (See also the introductory discussion on paradigms and trajectories in Chapter 2).

- (i) *Incremental innovations*: These types of innovation occur more or less continuously in any industry or service activity although at differing rates in different industries and different countries, depending upon a combination of demand pressures, socio-cultural factors, technological opportunities and trajectories. They may often occur, not so much as

the result of any deliberate research and development activity, but as the outcome of inventions and improvements suggested by engineers and other directly engaged in the production process, or as a result of initiatives and proposals by users ('learning by doing and 'learning by using'). Many empirical studies have confirmed their great importance in improving the efficiency in use of all factors of production, for example, Hollander's (1965) study of productivity gains in Du Pont rayon plants or Townsend's (1976) study of the Anderton shearer-loader in the British coal-mining industry. They are frequently associated with the scaling-up of plant and equipment and quality improvements to products and services for a variety of specific applications. Although their combined effect is extremely important in the growth of productivity, no single incremental innovation has dramatic effects, and they may sometimes pass unnoticed and unrecorded. However, their effects are apparent in the steady growth of productivity, which is reflected in input-output tables over time by changes in the coefficients for the existing array of products and services.

(ii) *Radical innovations*: These are discontinuous events and in recent times are usually the result of a deliberate research and development activity in enterprises and/or in university and government laboratories. There is no way in which nylon could have emerged from improving the production process in rayon plants or the woollen industry. Nor could nuclear power have emerged from incremental improvements to coal or oil-fired power stations. Radical innovations are unevenly distributed over sectors and over time, but our research did not support the view of Mensch (1975) that their appearance is concentrated particularly in periods of deep recessions in response to the collapse or decline of established markets (Freeman, Clark and Soete, 1982). But we would agree with Mensch that, whenever they may occur, they are important as the potential springboard for the growth of new markets, and for the surges of new investment associated with booms. They may often involve a combined product, process and organisational innovation. Over a period of decades radical innovations, such as nylon or 'the pill', may have fairly dramatic effects, i.e., they *do* bring about structural change but in terms of their aggregate economic impact they are relatively small and localised, unless a whole cluster of radical innovations are linked together in the rise of new industries and services, such as the synthetic materials industry or the semiconductor industry.

(iii) *Changes of 'technology system'*: These are far-reaching changes in technology, affecting several branches of the economy, as well as giving rise to entirely new sectors. They are based on a combination of radical and incremental innovations, together with *organisational* and *managerial* innovations affecting more than one or a few firms. Keirstead (1948), in his exposition of a Schumpeterian theory of economic development, introduced the concept of 'constellations' of innova-

tions, which were technically and economically interrelated. An obvious example is the cluster of synthetic materials innovations, petro-chemical innovations, machinery innovations in injection moulding and extrusion, and innumerable application innovations introduced in the 1920s, 1930s, 1940s and 1950s (Freeman, Clark and Soete, 1982).

(iv) *Changes in 'techno-economic paradigm' ('technological revolutions')*: Some changes in technology systems are so far-reaching in their effects that they have a major influence on the behaviour of the entire economy. A change of this kind carries with it many clusters of radical and incremental innovations, and may eventually embody a number of new technology systems. A vital characteristic of this fourth type of technical change is that it has *pervasive* effects throughout the economy, i.e. it not only leads to the emergence of a new range of products, services, systems and industries in its own right; it also affects directly or indirectly almost every other branch of the economy, i.e. it is a 'meta-paradigm'. We use the expression 'techno-economic' (Perez, 1983) rather than 'technological paradigm' (Dosi, 1982) because the changes involved go beyond engineering trajectories for specific product or process technologies and affect the input cost structure and conditions of production and distribution throughout the system. This fourth category corresponds to Nelson and Winter's concept of 'general natural trajectories' and, once established as the dominant influence on engineers, designers and managers, becomes a 'technological regime' for several decades. From this it is evident that we view Schumpeter's long cycles and 'creative gales of destruction' as a succession of 'techno-economic paradigms' associated with a characteristic institutional framework, which, however, only emerges after a painful process of structural change.

We now turn to an elaboration of the main characteristics of 'techno-economic' paradigms and their patterns of diffusion through long waves of economic development. As the following sections will attempt to show, a new techno-economic paradigm develops initially within the old, showing its decisive advantages during the 'downswing' phase of the previous Kondratiev cycle. However, it becomes established as a dominant technological regime only after a crisis of structural adjustment, involving deep social and institutional changes, as well as the replacement of the motive branches of the economy (Table 3.1).

'Key factor' inputs and change of techno-economic paradigm

As the last section has made clear, our conception of 'techno-economic paradigm' is much wider than 'clusters' of innovations or even of 'technological systems'. We are referring to a combination of interrelated product

and process, technical, organisational and managerial innovations, embodying a quantum jump in potential productivity for all or most of the economy and opening up an unusually wide range of investment and profit opportunities. Such a paradigm change implies a unique new combination of decisive technical *and* economic advantages.

Clearly one major characteristic of the diffusion pattern of a new techno-economic paradigm is its spread from the initial industries or areas of application to a much wider range of industries and services and the economy as a whole (Table 3.1). By 'paradigm' change we mean precisely a radical transformation of the prevailing engineering and managerial *common sense* for best productivity and most profitable practice, which is applicable in almost any industry (i.e. we are talking about a 'meta-paradigm').

The organising principle of each successive paradigm and the justification for the expression 'techno-economic paradigm' is to be found not only in a new range of products and systems, but most of all in the dynamics of the relative *cost* structure of all possible inputs to production. In each new techno-economic paradigm, a particular input or set of inputs, which may be described as the 'key factor' of that paradigm, fulfils the following conditions:

- (i) Clearly perceived low and rapidly falling relative cost. As Rosenberg (1975) and other economists have pointed out, small changes in the relative input cost structure have little or no effect on the behaviour of engineers, designers and researchers. Only major and persistent changes have the power to transform the decision rules and 'common sense' procedures for engineers and managers (Perez, 1985; Freeman and Soete, 1987).
- (ii) Apparently almost unlimited availability of supply over long periods. Temporary shortages may of course occur in a period of rapid buildup in demand for the new key factor, but the prospect must be clear that there are no major barriers to an enormous long-term increase in supply. This is an essential condition for the confidence to take major investment decisions which depend on this long-term availability.
- (iii) Clear potential for the use or incorporation of the new key factor or factors in many products and processes throughout the economic system; either directly or (more commonly) through a set of related innovations, which both reduce the cost and change the quality of capital equipment, labour inputs, and other inputs to the system.

We would maintain that this combination of characteristics holds today for microelectronics and we discuss this further in the section below on the 'information technology paradigm'. It held until recently for oil, which underlay the post-war boom (the 'fourth Kondratiev' upswing). Before that, and more tentatively, we would suggest that the role of key factor was played by low-cost steel in the third Kondratiev wave, by low-cost and

steam-powered transport in the 'Victorian' boom of the nineteenth century (Table 3.1, column 5—'Key factor industries. . .').

Clearly, every one of these inputs identified as 'key factors' existed (and was in use) long before the new paradigm developed. However, its full potential is only recognised and made capable of fulfilling the above conditions when the previous key factor and its related constellation of technologies give strong signals of diminishing returns and of approaching limits to their potential for further increasing productivity or for new profitable investment. (In quite different types of society and different historical circumstances, archaeologists have also recognised the crucial importance of 'key factors' in economic development in their classification of the 'Stone Age', 'Bronze Age' and 'Iron Age'.)

From a purely technical point of view, the explosive surge of interrelated innovations involved in a technological revolution could probably have occurred earlier and in a more gradual manner. But, there are strong economic and social factors at play that serve as prolonged containment first and as unleashing forces later. The massive externalities created to favour the diffusion and generalisation of the prevailing paradigm act as a powerful deterrent to change for a prolonged period (see Chapter 26 by Brian Arthur). It is only when productivity along the old trajectories shows persistent limits to growth and future profits are seriously threatened that the high risks and costs of trying the new technologies appear as clearly justified. And it is only after many of these trials have been obviously successful that further applications become easier and less risky investment choices.

The new key factor does not appear as an isolated input, but rather at the core of a rapidly growing system of technical, social and managerial innovations, some related to the production of the key factor itself and others to its utilisation. At first these innovations may appear (and may be in fact pursued) as a means for overcoming the specific bottlenecks of the old technologies, but the new key factor soon acquires its own dynamics and successive innovations take place through an intensive interactive process, spurred by the limits to growth which are increasingly apparent under the old paradigm (Table 3.1, column 7—'Limitations of previous techno-economic paradigm . . .'). In this way the most successful new technology systems gradually crystallise as a new 'ideal' type of production organisation which becomes the common sense of management and design, embodying new 'rules of thumb' and restoring confidence to investment decision-makers after a long period of hesitation.

Clearly, this approach differs radically from the dominant conceptualisation of changing factor costs in neo-classical economic theory, although it has points of contact, such as the persistent search for least-cost combinations of factor inputs to sustain or increase profitability. Most formulations of neo-classical theory put the main emphasis on varying combinations of labour and capital and on substitution between them, and implicitly or explicitly assume responsiveness even to small changes in

Table 3.1 A tentative sketch of some of the main characteristics of successive long waves (modes of growth)

1	2	3	4	5	6	7	8
Number	Approx. periodisation Upswing Downswing	Description	Main 'carrier branches' and induced growth sectors infra-structure	Key factor industries offering abundant supply at descending price	Other sectors growing rapidly from small base	Limitations of previous techno-economic paradigm and ways in which new paradigm offers some solutions	Organisation of firms and forms of cooperation and competition
First	1770s & 1780s to 1830s & 1840s 'Industrial revolution' 'Hard times'	Early mechanisation Kondratieff	Textiles Textile chemicals Textile machinery Iron-working and iron castings Water power Potteries Trunk canals Turnpike roads	Cotton Pig iron	Steam engines Machinery	Limitations of scale, process control and mechanisation in domestic 'putting out' system. Limitations of hand-operated tools and processes. Solutions offering prospects of greater productivity and profitability through mechanisation and factory organisation in leading industries.	Individual entrepreneurs and small firms (< 100 employees) competition. Partnership structure facilitates co-operation of technical innovators and financial managers. Local capital and individual wealth.
Second	1830s & 1840s to 1880s & 1890s Victorian prosperity	Steam power and railway Kondratieff	Steam engines Steamships Machine tools Iron Railway equipment	Coal Transport	Steel Electricity Gas Synthetic dyestuffs	Limitations of water power in terms of inflexibility of location, scale of production, reliability and range of	High noon of small-firm competition, but larger firms now employing thousands, rather than hundreds. As firms and
	'Great depression'		Railways World Shipping		Heavy engineering	applications, restricting further development of mechanisation and factory production to the economy as a whole. Largely overcome by steam engine and new transport system.	markets grow, limited liability and joint stock company permit new pattern of investment, risk-taking and ownership.
Third	1880s & 1890s to 1930s & 1940s 'Belle époque' 'Great depression'	Electrical and heavy engineering Kondratieff	Electrical engineering Electrical machinery Cable and wire Heavy engineering Heavy armaments Steel ships Heavy chemicals Synthetic dyestuffs Electricity supply and distribution	Steel	Automobiles Aircraft Telecommunications Radio Aluminium Consumer durables Oil Plastics	Limitations of iron as an engineering material in terms of strength, durability, precision, etc., partly overcome by universal availability of cheap steel and of alloys. Limitations of inflexible belts, pulleys, etc., driven by one large steam engine overcome by unit and group drive for electrical machinery, overhead cranes, power tools permitting vastly improved layout and capital saving. Standardisation facilitating world-wide operations	Emergence of giant firms, cartels, trusts and mergers. Monopoly and oligopoly became typical. 'Regulation' or state ownership of 'natural' monopolies and 'public utilities'. Concentration of banking and 'finance-capital'. Emergence of specialised 'middle management' in large firms.

Table 3.1—cont.

1	2	3	4	5	6	7	8
Number	Approx. periodisation Upswing Downswing	Description	Main 'carrier branches' and induced growth sectors infra-structure	Key factor industries offering abundant supply at descending price	Other sectors growing rapidly from small base	Limitations of previous techno-economic paradigm and ways in which new paradigm offers some solutions	Organisation of firms and forms of cooperation and competition
Fourth	1930s & 1940s to 1980s & 1990s Golden age of growth and Keynesian full employment Crisis of structural adjustment	Fordist mass production Kondratieff	Automobiles Trucks Tractors Tanks Armaments for motorised warfare Aircraft Consumer durables Process plant Synthetic materials Petro-chemicals Highways Airports Airlines	Energy (especially oil)	Computers Radar NC machine tools Drugs Nuclear weapons and power Missiles Micro-electronics software	Limitations of scale of batch production overcome by flow processes and assembly-line production techniques, full standardisation of components and materials and abundant cheap energy. New patterns of industrial location and urban development through speed and flexibility of automobile and air transport. Further cheapening of mass consumption products	Oligopolistic competition. Multinational corporations based on direct foreign investment and multi-plant locations. Competitive subcontracting on 'arms length' basis or vertical integration. Increasing concentration, divisionalisation and hierarchical control. 'Techno-structure' in large corporations.
Fifth*	1980s & 1990s to ?	Information and communication Kondratieff	Computers Electronic capital goods Software Tele-communications equipment Optical fibres Robotics FMS Ceramics Data banks Information services Digital tele-communications network Satellites	'Chips' (micro-electronics)	Third generation' biotechnology products and processes Space activities Fine chemicals SDI	Diseconomies of scale and inflexibility of dedicated assembly-line and process plant partly overcome by flexible manufacturing systems, 'networking' and 'economies of scope'. Limitations of energy intensity and materials intensity partly overcome by electronic control systems and components. Limitations of hierarchical departmentalisation overcome by 'systemation', 'networking' and integration of design, production and marketing.	'Networks' of large and small firms based increasingly on computer networks and close co-operation in technology, quality control, training, investment planning and production planning ('just-in-time') etc. 'Keiretsu' and similar structures offering internal capital markets.

*All columns dealing with the "fifth Kondratieff" are necessarily speculative

Table 3.1—cont.

9	10	11	12	13	14	15	16	17
Number	Technological leaders	Other industrial and newly industrialising countries	Some features of national regimes of regulation	Aspects of the international regulatory regime	Main features of the national system of innovation	Some features of tertiary sector development	Representative innovative entrepreneurs engineers	Political economists and philosophers
First	Britain France Belgium	German states Netherlands	Breakdown and dissolution of feudal and medieval monopolies, guilds, tolls, privileges and restrictions on trade, industry and competition. Repression of unions. Laissez-faire established as dominant principle.	Emergence of British supremacy in trade and international finance with the defeat of Napoleon.	Encouragement of science through National Academies, Royal Society, etc. Engineer and inventor-entrepreneurs and partnerships. Local scientific and engineering societies. Part-time training and on-the-job training. Reform and strengthening of national patent systems. Transfer of technology by migration of skilled workers. British Institution of Civil Engineers. Learning by doing, using and interacting	Rapid expansion of retail and wholesale trade in new urban centres. Very small state apparatus. Merchants as source of capital	Arkwright Boulton Wedgwood Owen Bramah Maudslay	Smith Say Owen
Second	Britain France Belgium Germany USA	Italy Netherlands Switzerland Austria-Hungary	High noon of laissez-faire. 'Nightwatchman state' with minimal regulatory	'Pax Britannica'. British naval, financial and trade dominance.	Establishment of Institution of Mechanical Engineers and development of UK Mechanics' Institutes. More rapid development of professional education and	Rapid growth of domestic service for new middle class to largest service occupation. Continued rapid	Stephenson Whitworth Brunel Armstrong Whitney Singer	Ricardo List Marx
Third	Germany USA Britain France Belgium Switzerland Netherlands	Italy Austria-Hungary Canada Sweden Denmark Japan Russia	functions except protection of property and legal framework for production and trade. Acceptance of craft unions. Early social legislation and pollution control. Nationalist and imperialist state regulation or state ownership of basic infrastructure (public utilities). Arms race. Much social legislation. Rapid growth of state bureaucracy.	International free trade. Gold standard. Imperialism and colonisation. 'Pax Britannica' comes to an end with First World War. Destabilisation of international financial and trade system leading to world crisis and Second World War.	training of engineers and skilled workers elsewhere in Europe. Growing specialisation. Internationalisation of patent system. Learning by doing, using and interacting 'In-house' R and D departments established in German and US chemical and electrical engineering industries. Recruitment of university scientists and engineers and graduates of the new Technische Hochschulen and equivalent Institutes of Technology. National Standard Institutions and national laboratories. Universal elementary education. Learning by doing, using and interacting	growth of transport and distribution. Universal postal and communication services. Growth of financial services Peak of domestic service industry. Rapid growth of state and local bureaucracies. Department stores and chain stores. Education tourism, and entertainment expanding rapidly. Corresponding take-off of white-collar employment pyramid. London as centre for major world commodity markets.	Siemens Carnegie Nobel Edison Krupp Bosch	Marshall Pareto Lenin Veblen

Table 3.1—cont.

9	10	11	12	13	14	15	16	17
Number	Technological leaders	Other industrial and newly industrialising countries	Some features of national regimes of regulation	Aspects of the international regulatory regime	Main features of the national system of innovation	Some features of tertiary sector development	Representative innovative entrepreneurs engineers	Political economists and philosophers
Fourth	USA Germany Other EEC Japan Sweden Switzerland USSR Other EFTA Canada Australia	Other Eastern European Korea Brazil Mexico Venezuela Argentina China India Taiwan	'Welfare state' and 'warfare state'. Attempted state regulation of investment, growth and employment by Keynesian techniques. High levels of state expenditure and involvement. 'Social partnership' with unions after collapse of fascism. "Roll-back" of welfare state deregulation and privatisation during crisis of adjustment	'Pax Americana' US economic and military dominance. Decolonisation. Arms race and cold war with USSR. US-dominated international financial and trade regime (GATT, IMF, World Bank). Destabilisation of Bretton Woods regime in 1970s	Spread of specialised R and D departments to most industries. Large-scale state involvement in military R and D through contracts and national laboratories. Increasing state involvement in civil science and technology. Rapid expansion of secondary and higher education and of industrial training. Transfer of technology through extensive licensing and know-how agreements and investment by multinational corporations. Learning by doing using and interacting.	Sharp decline of domestic service. Self-service fast food and growth of super-markets and hypermarkets, petrol service stations. Continued growth of state bureaucracy, armed forces and social services. Rapid growth of research and professions and financial services, packaged tourism and air travel on very large scale.	Sloan McNamara Ford Agnelli Nordhoff Matsushita	Keynes Schumpeter Kalecki
Fifth*	Japan USA Germany Sweden Other EEC EFTA USSR and other Eastern European Taiwan Korea Canada Australia	Brazil Mexico Argentina Venezuela China India Indonesia Turkey Egypt Pakistan Nigeria Algeria Tunisia Other Latin American	'Regulation' of strategic ICT infrastructure. 'Big Brother' or 'Big Sister' state. Deregulation and reregulation of national financial institutions and capital markets. Possible emergence of new-style participatory decentralised welfare state based on ICT and red-green alliance.	'Multi-polarity'. Regional blocs. Problems of developing appropriate international institutions capable of regulating global finance, capital, ICT and transnational companies.	Horizontal integration of R and D, design, production and process engineering and marketing. Integration of process design with multi-skill training. Computer networking and collaborative research. State support for generic technologies and university-industry collaboration. New types of proprietary regime for software and biotechnology. 'Factory as laboratory'.	Rapid growth of new information services, data banks and software industries. Integration of services and manufacturing in such industries as printing and publishing. Rapid growth of professional consultancy. New forms of craft production linked to distribution.	Kobayashi Uenohara Barron Benneton Noyce	Schumacher Aoki Bertalanffy

*All columns dealing with the "fifth Kondratieff" are necessarily speculative

Source: based on Freeman (1987)

these relative factor prices in either direction, i.e. 'reversibility'. Our approach stresses the system's response to *major* changes in the price of *new* inputs, and *new* technologies which exploit their potential to reduce costs of both labour and capital, as a result of new total factor input combinations and organisational-managerial innovations. Such major changes are the result of an active and prolonged search in response to perceived limits, not on the basis of perfect information but on the basis of trial and error, i.e. the historical learning process stressed by Hahn (see Chapter 1). Once the new technology is widely adopted, the change is generally irreversible (i.e. the principal actors became 'locked in' by the pervasive economic and technical advantages and complementarities; (see Chapter 26).

We have stressed the role of a key factor or factors in creating widening investment opportunities and creating the potential for big increases in productivity and profits. We turn now to consider the wider societal problems involved in the transition from one 'techno-economic paradigm' to another.

Diffusion of new techno-economic paradigms and institutional change

It is a clear implication of our mode of conceptualising successive 'techno-economic paradigms' that a new paradigm emerges in a world still dominated by an old paradigm and begins to demonstrate its comparative advantages at first only in one or a few sectors. The fastest-growing new sectors are thus *not* those which are the motive branches of an established, technological regime (Table 3.1, columns 5—'Main "carrier branches"' and 6—'Other sectors growing rapidly'). There is no possibility of a new paradigm displacing an old one until it has first clearly demonstrated such advantages and until the supply of the new key factor or factors already satisfies the three conditions described above: falling costs, rapidly increasing supply, and pervasive applications. Thus a period of rapid growth in the supply of the key factor(s) occurs already *before* the new paradigm is established as the dominant one, and continues when it is the prevailing regime.

A new techno-economic paradigm emerges only gradually as a new 'ideal type' of productive organisation, to take full advantage of the key factor(s) which are becoming more and more visible in the relative cost structure. The new paradigm discloses the potential for a quantum jump in total factor productivity and opens up an unprecedented range of new investment opportunities. It is for these reasons that it brings about a radical shift in engineering and managerial 'common sense' and that it tends to diffuse as rapidly as conditions allow, replacing the investment pattern of the old paradigm.

The full constellation—once crystallised—goes far beyond the key factor(s) and beyond technical change itself. It brings with it a restructuring of the whole productive system.

Among other things as it crystallises, the new techno-economic paradigm involves:

- (a) a new 'best-practice' form of organisation in the firm and at the plant level;
- (b) a new skill profile in the labour force, affecting both quality and quantity of labour and corresponding patterns of income distribution;
- (c) a new product mix in the sense that those products which make intensive use of the low-cost key factor will be the preferred choice for investment and will represent therefore a growing proportion of GNP;
- (d) new trends in both radical and incremental innovation geared to substituting more intensive use of the new key factor(s) for other relatively high-cost elements;
- (e) a new pattern in the location of investment both nationally and internationally as the change in the relative cost structure transforms comparative advantages;
- (f) a particular wave of infra-structural investment designed to provide appropriate externalities throughout the system and facilitate the use of the new products and processes everywhere;
- (g) a tendency for new innovator-entrepreneur-type small firms also to enter the new rapidly expanding branches of the economy and in some cases to initiate entirely new sectors of production;
- (h) a tendency for large firms to concentrate, whether by growth or diversification, in those branches of the economy where the key factor is produced and most intensively used, which results in there being distinctly different branches acting as the engines of growth in each successive Kondratiev upswing;
- (i) a new pattern of consumption of goods and services and new types of distribution and consumer behaviour.

From this it is evident that the period of transition—the downswing and depression of the long wave—is characterised by deep structural change in the economy and such changes require an equally profound transformation of the institutional and social framework. The onset of prolonged recessionary trends indicate the increasing degree of mismatch between the techno-economic sub-system and the old socio-institutional framework. It shows the need for a full-scale reaccommodation of social behaviour and institutions to suit the requirements and the potential of a shift which has already taken place to a considerable extent in some areas of the techno-economic sphere. This reaccommodation occurs as a result of a process of political search, experimentation and adaptation, but when it has been achieved, by a variety of social and political changes at the national and international level, the resulting good 'match' facilitates the upswing phase of the long wave. A climate of confidence for a surge of new investment is created through an appropriate combination of regulatory mechanisms which foster the full deployment of the new paradigm. Since the achievement of a 'good match' is a conflict-ridden process and proceeds very

unevenly in differing national political and cultural contexts, this may exert a considerable influence on the changing pattern of international technological leadership and international patterns of diffusion (Table 3.1 and Chapter 23).

Schumpeter's (1939) theory of depression was rather narrowly 'economic' and strangely, for someone who was so much aware of social and organisational aspects of technical innovation, tended to ignore the institutional aspects of recovery policies. This was one of the main reasons for the relative neglect of his ideas compared with those of Keynes.

The information technology paradigm

The technological regime, which predominated in the post-war boom, was one based on low-cost oil and energy-intensive materials (especially petrochemicals and synthetics), and was led by giant oil, chemical, automobile and other mass durable goods producers. Its 'ideal' type of productive organisation at the plant level was the continuous-flow assembly-line turning out massive quantities of identical units. The 'ideal' type of firm was the 'corporation' with a separate and complex hierarchical managerial and administrative structure, including in-house R & D and operating in oligopolistic markets in which advertising and marketing activities played a major role. It required large numbers of middle-range skills in both the blue- and white-collar areas, leading to a characteristic pattern of occupations and income distribution. The massive expansion of the market for consumer durables was facilitated by this pattern, as well as by social changes and adaptation of the financial system, which permitted the growth of 'hire purchase' and other types of consumer credit. The paradigm required a vast infrastructural network of motorways, service stations, airports, oil and petrol distribution systems, which was promoted by public investment on a large scale already in the 1930s, but more massively in the post-war period. At various times in different countries both civil and military expenditures of governments played a very important part in stimulating aggregate demand, and a specific pattern of demand for automobiles, weapons, consumer durables, synthetic materials and petroleum products.

Today, with cheap microelectronics widely available, with prices expected to fall still further and with related new developments in computers and telecommunications, it is no longer 'common sense' to continue along the (now expensive) path of energy and material-intensive inflexible mass production.

The 'ideal' information-intensive productive organisation now increasingly links design, management, production and marketing into one integrated system—a process which may be described as 'systemation' and which goes far beyond the earlier concepts of mechanisation and automation. Firms organised on this new basis, whether in the computer industry

such as IBM, or in the clothing industry such as Benetton, can produce a flexible and rapidly changing mix of products and services. Growth tends increasingly to be led by the electronics and information sectors, taking advantage of the growing externalities provided by an all-encompassing telecommunications infrastructure, which will ultimately bring down to extremely low levels the costs of access to the system for both producers and users of information.

The skill profile associated with the new techno-economic paradigm appears to change from the concentration on middle-range craft and supervisory skills to increasingly high- and low-range qualifications, and from narrow specialisation to broader, multi-purpose basic skills for information handling. Diversity and flexibility at all levels substitute for homogeneity and dedicated systems.

The transformation of the profile of capital equipment is no less radical. Computers are increasingly associated with all types of productive equipment as in CNC machine tools, robotics, and process control instruments as well as with the design process through CAD, and with administrative functions through data processing systems, all linked by data transmission equipment. According to some estimates computer-based capital equipment already accounts for nearly half of all new fixed investment in plant and equipment in the United States.

The deep structural problems involved in this change of paradigm are now evident in all parts of the world. Among the manifestations are the acute and persistent shortage of the high-level skills associated with the new paradigm, even in countries with high levels of general unemployment, and the persistent surplus capacity in the older 'smokestack', energy-intensive industries such as steel, oil and petrochemicals.

As a result there is a growing search for new social and political solutions in such areas as flexible working time, shorter working hours, re-education and retraining systems, regional policies based on creating favourable conditions for information technology (rather than tax incentives to capital-intensive mass production industries), new financial systems, possible decentralisation of management and government, and access to data banks and networks at all levels and new telecommunication systems. But so far, these seem still to be partial and relatively minor changes. If the Keynesian revolution and the profound transformation of social institutions in the Second World War and its aftermath were required to unleash the fourth Kondratiev upswing, then social innovations on an equally significant scale are likely to be needed now. This applies especially to the international dimension of world economic development.

The structural crisis of the 1980s

From this brief summary of some of the characteristics of the new paradigm it will have become apparent that the widespread diffusion of the

new technology throughout the economic system is not just a matter of incremental improvements, nor just a question of the extension of existing capacity in a few new industries. It involves a major upheaval in *all* sectors of the economy and changes in the skill profile and capital stock throughout the system. It is for this reason that periods like the 1930s and the 1980s cannot be treated in the same way as the minor recessions of the 1950s and 1960s.

The structural crisis involved in the transition from one technological regime to another increases the instability of investment behaviour for a number of reasons. The leading-edge industries of the new paradigm are growing so rapidly that they constantly tend to outstrip the supply of skilled labour. However, the headlong rush to increase capacity as bandwagons get rolling also leads to periodic crises of over-capacity, as there is no way in which the supply can precisely anticipate and match smoothly the growth of market demand (in Hahn's terminology, the 'true' demand function cannot be known). Moreover the technology is still changing so rapidly that successive generations of equipment and products rapidly become obsolete. The tempestuous growth of the chip industry and the computer industry in the 1970s and 1980s has also been marked by periodic, though short-lived, crises of over-supply (Ernst, 1983, 1987). There were similar problems with the leading-edge industries of the 1920s and the 1930s—automobiles, consumer durables and organic chemicals.

The problems in the other sectors of the economy are even more severe. Some industries which have previously been at the heart of the (now superseded) paradigms now experience much slower rates of growth or absolute decline. They may also have problems of over-capacity and rationalisation which are prolonged, as has been the case in some of the energy-intensive industries in the 1970s and 1980s, such as steel, petrochemicals and synthetic fibres. Similar problems were encountered by the railways and railway equipment industries as well as by coal and textiles in previous structural crises.

There are also severe problems in those manufacturing and service sectors which still have ample growth potential but are confronted with the need to change their production processes, their product mix, their management systems, their skill profiles and their marketing to accomplish the shift to an entirely new technological paradigm. This is a painful and difficult process of adjustment, involving, as we have seen, a kind of cultural revolution as well as the need for major re-equipment. These problems can be seen very clearly today in such industries as printing, vehicles and machine tools, as well as in services such as insurance, distribution and transport. They were equally apparent in many industrial sectors adapting in the 1920s and 1930s to the new energy-intensive mass and flow production systems which at that time represented the leading edge of the new techno-economic paradigm.

The depression of the 1930s was certainly one of extraordinary severity, especially in the leading industrialised countries—the United States and

Germany. Between 1929 and 1933 GNP fell by 30 per cent in the United States, industrial production by nearly 50 per cent, output of durable producers' equipment by 75 per cent and new construction by 85 per cent. It is hardly surprising that Keynesian economists, such as Samuelson (1980), discount the likelihood of the recurrence of such a catastrophe:

Although nothing is impossible in an inexact science like economics, the probability of a great depression—a prolonged cumulative chronic slump like that of the 1930s, 1890s or 1870s—has been reduced to a negligible figure. No one should pay an appreciable insurance premium to be protected against the risk of a total breakdown in our banking system and of massive unemployment in which 25 per cent of workers are jobless. The reason for the virtual disappearance of great depressions is the new attitude of the electorate . . . The electorate in a mixed economy insists that any political party which is in power—be it Republican or Democratic, the Tory or Labour Party—take the expansionary actions that can prevent lasting depressions. [p. 251]

This may be an over-optimistic view. Whilst not dissenting from Samuelson's description of economics as an inexact science, this chapter suggests that it is quite possible for the world economy to experience a depression, which, even if not so severe in all respects as that of the 1930s, could be more severe than the earlier recessions of the 1870s and the 1890s.

This somewhat pessimistic view is based on the observation that the main sources of instability which gave rise to the depression of the 1930s are also present today, albeit in a somewhat different form: the international debt situation, extreme imbalances in international payments, weakness in agricultural prices, instability in exchange rates, creeping protectionism, the absence of an adequate system of regulating the international economy and in particular the absence of an adequate international lender of last resort, disarray in the economics profession, and lack of long-term vision in policy-making. The present wave of technical change sweeping through the world economy is likely to exacerbate the problems of instability in investment, and of structural change at the national and international level and the associated disequilibria in the international economy.

It is notable that Samuelson's argument that severe depressions can be averted rests not on any faith in the self-regulating powers of the market, but unequivocally on the belief that *political* factors, principally the level of unemployment, will put pressure on governments to adopt expansionary policies, which are assumed to be available and applicable. We share with him and other Keynesians their scepticism that the rate of interest and monetary policy are in themselves sufficient to achieve an equilibrium growth path.

But for his argument to carry conviction it would be necessary not only for governments to adopt *national* policies to counteract tendencies toward depression, but also at least for the leading countries to act in a co-ordinated manner at the *international* level. Recent experience must cast

some doubt on both these assumptions. It is no doubt true that the experience of recession and stagnation does induce a search for expansionary policies at the political level. But, as in the 1930s, this search may lead to nationalistic, protectionist and even militaristic policies as well as to neo-Keynesian policies and other as yet untried solutions. It may also be hindered by the extreme divergence of views from the economics profession on such questions as the feasibility and desirability of a return to fixed exchange rates.

The uneven and varied response of governments, firms and industries to the threats and opportunities posed by information technology tends to accentuate the uneven process of development. Typically in the past, major changes in techno-economic paradigm have been associated with shifts in the international division of labour and international technological leadership. Newcomers are sometimes more able to make the necessary social and institutional innovations than the more arthritic social structures of established leaders. Erstwhile leading countries such as the United Kingdom or the United States may become the victims of their own earlier success. On the other hand, countries lacking the necessary minimal educational, managerial, R & D and design capability may be even more seriously disadvantaged in international competition.

This means that changes of paradigm are likely to be associated with the temporary aggravation of instability problems in relation to the flow of international investment, trade and payments. The enormous Japanese trade surplus and the US trade deficit reflect not merely exchange rate problems, but also the more successful Japanese exploitation and application of IT outside the leading-edge industries, and the introduction of many institutional innovations facilitating this process (Chapter 23). The US economy leads in military applications of IT but lags in other areas. There is thus a major 'structural' component in the international trade imbalances, as there was in the 'technological gap' which the United States opened up between the 1920s and the 1950s (Freeman, 1987).

The same is even more true of the problems of Third World countries. A report of the Inter-American Development Bank has highlighted these critical problems confronting the world economy and has warned that the IMF measures to deal with the crisis have been short-term palliatives, not long-term solutions. Albert Fishlow (1985) points out that Latin America faces a burden of debt service repayments greater than the level of reparations that Germany found impossible after the First World War. Only a widespread recovery of productive investment and technical innovation in Latin America could sustain the growth needed to finance even a much lower level of debt repayment and interest payments. It is not without interest that Samuelson and Nordhaus in the 12th edition of *Economics* (1985) do introduce a sentence or two suggesting that 'default of major heavily indebted countries' could lead to a Great Depression.

The Third World countries are experiencing difficulties in developing the new information technology industries to sustain their competitive power,

but the new technologies do actually offer some major advantages to them, provided they modify their trade, industrial and technology policies, as indicated in Chapter 21 by Perez and Soete.

However, these 'catching up' efforts of Third World countries also require some resolution of the basic structural problems confronting the entire world economy. This implies new measures to facilitate the international transfer of technology as well as a resolution of the debt problem. Thus the greatest problem of institutional adaptation lies in the sphere of international financial and economic institutions, to take account of these long-term structural adaptation difficulties. The development of new national and international 'regimes of regulation' is discussed in the following chapter by Boyer.

References

- Dosi, G (1982), 'Technological paradigms and technological trajectories', *Research Policy*, vol. II, no. 3, June, pp. 147-162.
- Eatwell, J. (1982), *'Whatever Happened to Britain?'*, London, Duckworth.
- Elliot, J.E. (1985), 'Schumpeter's theory of economic development and social change: exposition and assessment', *International Journal of Social Economics*, vol. 12, Parts 6 and 7, p. 6-33.
- Ernst, D. (1983), 'The global race in microelectronics: innovation and corporate strategies in a period of crisis', MIT.
- (1987), 'Programmable automation in the semiconductor industry: reflections on current diffusion patterns', GERTTD Conference on Automisation Programmable, Paris, 12-14 April 1987.
- Freeman, C. (1987), *Technology Policy and Economic Performance: Lessons from Japan*, London, Pinter.
- Freeman, C., Clark, J. and Soete, L.L.G. (1982), *Unemployment and Technical Innovation: A Study of Long Waves in Economic Development*, London, Frances Pinter.
- Freeman, C. and Soete, L.L.G. (eds) (1987), *Technical Chance and Full Employment*, Oxford, Blackwell.
- Galbraith, J.K. (1961), *The Great Crash, 1929*, Harmondsworth, Pelican.
- Hollander, S.G. (1965), *The Sources of Increased Efficiency: A Study of DuPont Rayon Plants*, Cambridge, Mass., MIT Press.
- Jewkes, J., Sawers, D. and Stillerman, J. (1956), *The Sources of Invention*, London, Macmillan.
- Keirstead, B.S. (1948), *The Theory of Economic Change*, Toronto, Macmillan.
- Keynes, J.M. (1930), *A Treatise on Money*, vol. 2, London, Macmillan, p. 86.
- (1936), *General Theory of Employment, Interest and Money*, New York, Harcourt Brace.
- Klamer, A. (1984) *The New Classical Macroeconomics*, Brighton, Wheatsheaf.
- Kuznets, S. (1940), 'Schumpeter's business cycles', *American Economic Review*, vol. 30, no. 2, p. 257-71.
- Mensch, G. (1975), *Das Technologische Patt: Innovation Überwinden die Depression*, Frankfurt, Umschau; English edn: *Stalemate in Technology: Innovations overcome Depression*, New York, Ballinger, (1979).

- Moggridge, D.E. (1976), *Keynes*, London, Fontana.
- Nelson, R.R. and Winter, S.G. (1977), 'In search of a useful theory of innovation', *Research Policy*, vol. 6, no. 1, pp. 36-76.
- Perez, C. (1983), 'Structural change and the assimilation of new technologies in the economic and social system', *Futures*, vol. 15, no. 4, October, pp. 357-75.
- (1985), 'Microelectronics, long waves and world structural change', *World Development*, vol. 13, no. 3, pp. 441-63.
- (1986), 'The new technologies: an integrated view'; original Spanish in C. Omanani (ed.), *La Tercera Revolución Industrial*, Buenos Aires.
- Rosenberg, N. (1975), *Perspectives on Technology*, Cambridge, Cambridge University Press.
- Samuelson, P. (1980), *Economics*, 11th edn., New York, McGraw-Hill.
- (1981), 'The world's economy at century's end', *Japan Economic Journal*, 10 March, p. 20.
- Samuelson, P. and Nordhaus, W. (1985), *Economics*, 12th edn., New York, McGraw-Hill.
- Shackle, G.L.S. (1967), 'To the *QJE* from Chapter 12 of the general theory: Keynes' "Ultimate Meaning", in Shackle, G.L.S. (ed.), *The Years of High Theory: Invention and Tradition in Economic Thought 1926-1939*, Cambridge, Cambridge University Press. (Shackle refers to the article of J.M. Keynes on 'The general theory of employment' in the *QJE* (1937), February, pp. 209-23.)
- Schumpeter, J.A. (1939), *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process*, 2 vols, New York, McGraw-Hill.
- (1952), *Ten Great Economists*, Allen & Unwin, London.
- Siegenthaler, H. (1986), 'The state of confidence and economic behaviour in the 30s and 70s: theoretical framework—historical evidence', in I.T. Berend and K. Borchardt (eds) (1986), *The Impact of the Depression of the 1930s and its Relevance for the Contemporary World*, papers of Section 5 of the International Economic History Congress, Berne, pp. 409-37.
- Soete, L.L.G. and Dosi, G. (1983), *Technology and Employment in the Electronics Industry*, London, Frances Pinter.
- Townsend, J. (1976), *Innovations in Coal-Mining Machinery: The Anderton Shearer-Loader and the Role of the NCB and Supply Industry in its Development*, SPRU Occasional Paper No. 3.