6. Uneven Development and Time-Lags in Diffusion

Since the end of the nineteenth century, there have been several attempts at recognizing and explaining the occurrence of 50–60-year cycles or long waves in economic growth, generally associated with the name of Nicolai Kondratiev, who in the 1920s made an attempt at systematically measuring the phenomenon.[75] The debates have continued ever since, both about their very existence and about their possible causes.[76] On the whole, long-wave interpretations have been bogged down by three conceptual shortcomings involving expectations that cannot be fulfilled:

1. the attempt to confine the analysis of the long wave within a narrowly defined economic system and to search for endogenous causes;
2. the insistence on finding regular up and downswings in GNP and other aggregate variables; and
3. the conviction that such cycles must be simultaneous worldwide phenomena.

The model being presented here avoids these three ideas considering them misleading directions of research.

The first point has already been addressed by suggesting that long waves are not economic cycles but a much wider systemic phenomenon where social and institutional factors play a key role by first resisting and then facilitating the unfolding of the potential of each technological revolution. This difference led to proposing the term 'great surges' to shift the focus from economic measurement to the qualitative understanding of the complex tensions and forces involved in the process of assimilating change.[77] Moreover, the very occurrence of those big revolutionary leaps in technology has been explained here

75. Kondratiev (1926).
76. For a discussion of the various positions in the long-wave debate and a reassessment of the data and the dating, see Van Duijn (1983). For collections of the main papers, with introductions about the different approaches, see Freeman (ed.) (1996) and Louçã and Reijnders (eds) (1999).
77. Freeman and Louçã (2001) also express dissatisfaction with the long-wave metaphor but continue to use the expression because it has become the established framework for the discussion of long-term structural change.

by a combination of economic pressures and s*ocial* 'overadaptation'. The other two points will be addressed below.

A. Uneven and Differentiated Growth Patterns Rather than Long Swings in the Aggregate

In the present model there is no expectation of neat upswings and downswings in GNP or in any other economic aggregate. This coincides with Schumpeter's own view that aggregate figures conceal more than they reveal.[78] In fact, it is not even likely that the turbulent process by which new paradigms are assimilated should lead to regular up and down trends in the economy as a whole.

The phenomenon being analyzed can only express itself in the inner workings of the economy, where increasing differentiation takes place. Some new branches will be growing at astonishingly high rates while many others will be declining, stagnating or growing slowly. So the expectation would be of an internal loss of synchrony between new and old branches as a feature of the two or three decades of the installation period and of resynchronizing and synergy as the mark of the deployment period (especially in the early phase). After the irruption of the technological revolution, a divergence in trends would be observed between the modern or modernized activities and those that have become old and traditional. This divergence would slowly decrease during Frenzy, as more and more firms adopt the paradigm. Whether the sum of these differing trends comes out as a 'downswing' or not depends on the changing relative weights and relative growth rates.[79]

A further complication arises from the fact that most of the measuring attempts use money values (sometimes with constructed 'constant' values). This is not valid for a simple reason: the quantum jump in productivity brought about by a technological revolution leads during the period of installation to the coexistence of 'two moneys' operating under the guise of one. The change in the relative price structure is radical and centrifugal. Money buying electronics and telecommunications today does not have the same value as money buying furniture or automobiles, and the difference has been growing since the early 1970s. The price of steel, in the installation period of the third surge, came down because of immense increases in productivity, while that of iron was forced down by competition in the market.[80]

Rates of inflation or deflation during installation periods are chaotic and all

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78. Schumpeter (1939) Vol.1, pp. 43–4.
79. Chris Freeman has often remarked that ignoring the weight–rate relationship is behind many of the arguments about whether technological revolutions or long waves really occur and whether they can be measured in the statistics.
80. Wells (1889:1893) p. 43.

statistical efforts to construct constant money series, in spite of their sophistication, are doubtful to say the least. Volume, which is the usual way of attempting constancy, is an elusive measure in many cases. How do you compare one computer in the 1960s with one in the 1970s, in the 1980s and now? How do you measure the volume of communications? In the nineteenth century, was money paying for transport by railway comparable to that by horses? Was telegraph or telephone to India comparable to mail by ship? When costs are violently decreasing and qualities increasing and changing, comparability is quite impossible and aggregates are disparate. People living through the period of paradigm transition experience great uncertainty as to the 'right' price of things (including that of stocks, of course). It is only when the productivity levels become comparable across the economy, during the deployment period, that the single money economy returns, the relations between components of the relative cost structure become stable again and constant money indexes can be safely constructed (at least for a while).

It would in fact be justified to assert that long-term aggregate series, truly long-term ones, attempting to span two or three paradigms in terms of money, are senseless. Thus, the efforts at testing the long-wave hypothesis through manipulating such series are in a trap. Yet, the sort of disaggregated statistics that would be appropriate are rarely available.

Nevertheless, the present interpretation *does* expect a set of increasingly coherent trends in the synergy phase, with a certain level of stability of the relative productivities of groups of branches (some consistently higher, some consistently lower; most growing), which could appear as an 'upswing' in the aggregate.

But such clean figures do not last long in the unstable scene of the capitalist economy. By the maturity phase, there is a mixture of dynamic growth in the latecomer branches and sluggish growth in the now 'traditional' core industries of the paradigm (although this difference might not be obvious in profit terms, due to oligopolistic price behavior and market manipulation on the part of the larger firms). So, even what might look like peak overall growth already contains contradictory trends.

B. Delayed Sequences in the Spread of Technologies Across the World

The third misleading direction of some long-wave proponents is to expect the phenomenon to coincide in time worldwide. Kondratiev himself tended to believe in this near synchronicity. After asserting that the long waves he had established, 'relative to the series most important in economic life, are international; and the timing of these cycles corresponds fairly well for European

capitalist countries', he added that, though the USA may have peculiarities, 'we can venture ... that the same timing holds also for the United States'.[81]

What is held in this book is that, though major crises tend to be nearly simultaneous across industries and the world, because of instant transmission of the violent contraction of markets, most diffusion processes are sequential and lagged, taking the form of wider and wider ripples of propagation. As paradigms mature in the core countries, investment opportunities move further and further out, seeking comparative advantages, different conditions and possibilities for outstretching saturated markets.

It would seem that each paradigm spreads in ripple-like fashion,[82] both from sector to sector across the industrial structure and geographically inside each country and across the world.

In terms of its sectoral impact, each technological revolution begins with a group of core industries, usually involving some energy source or another all-pervasive input, a new infrastructure and a few main products and processes.[83] From there it spreads to the most closely connected industries forming a strongly interactive constellation with very high synergy and intensive feedback effects. This helps the generic elements of the paradigm become clear and well tested, facilitating their adoption by a wider circle of industries and activities. This, in turn, strengthens the externalities and lowers the cost of adoption for an ever-wider circle and, as institutional conditions become favorable, the whole fabric of the economy tends to adopt the paradigm following its general innovative trajectories until they are seen as the 'natural way' of doing things effectively, efficiently and profitably.

Geographically the process has been rather similar. The revolution has generally irrupted in the core country of the previously prevailing paradigm, and spreads there first and then propagates to the periphery. The third surge, however, is an example of how the processes of either forging ahead and vying for pre-eminence or catching up from behind, which are more likely to happen when riding the new technologies from the beginning, can modify the expected sequences. From the 1870s the technological revolution diffused much faster and went much deeper in the USA and Germany than in Britain, which was still the financial, commercial, political and military world leader. This created an uneasy triple core for several decades. Whichever the core, the installation period is very much marked by the polarization between the front-running

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81. Kondratiev (1926:1979) p. 535.
82. There are problems with metaphors such as waves and ripples because they suggest an underlying steady state. For a discussion, see Freeman and Louçã (2001) Ch. 4.
83. The actual process of gestation of each technological revolution goes far back before its big-bang, though for the present purposes the visible crystallization is the most important. For the complete sequence of the life cycle, see Freeman and Louçã (2001) p. 146.

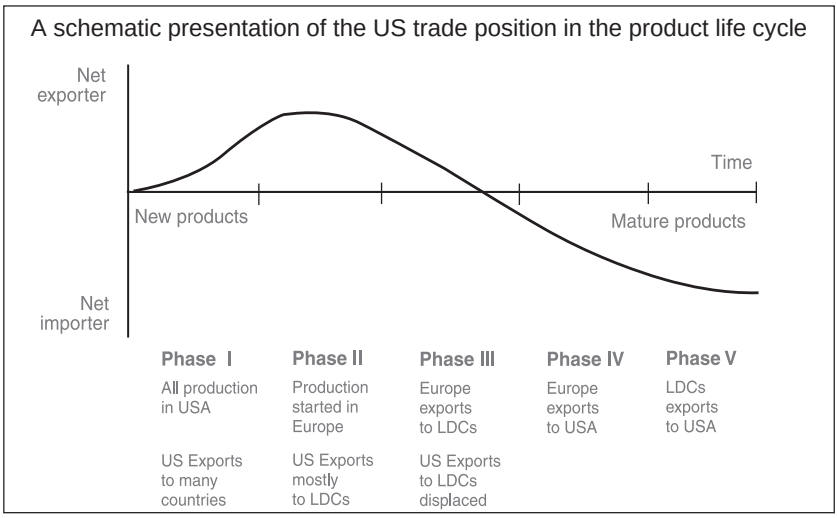
country or countries, where the new industries are being deployed, and those areas of the world that are left out and falling behind.

During Synergy, investment concentrates in the core countries, where the whole economy is flourishing and opportunities across the complete industrial spectrum now abound. It is a time of aggressive exports from the core countries and the growth that occurs in the far peripheries is generally tied to the production of inputs for the requirements of that paradigm (cotton, metals, grain, meat, oil and so on).

When Maturity arrives, though, as technologies gradually lose dynamism and markets begin to stagnate, the surge of growth moves to the near periphery and later even to the farther peripheries that had had little chance of industrializing until then.

The process is akin to what Wells depicted in his diagram (Figure 6.1) in relation to single products in the USA economy (and referring to observations made in the years before 1972, which are those of Maturity).

Figure 6.1 The geographic outspreading of technologies as they mature



Source: Wells (ed.) (1972), p.15. Reprinted by permission of the publisher Copyright © 1972 by the President and Fellows of Harvard College.

This means that the 'miracles' of synergy, intensive growth and prosperity fueled by each technological revolution, move out to further and further rings, from the areas of maximum development towards the least developed. This could be considered as the last manifestations of widespread world convergence with the final stage of diffusion of that particular paradigm. Though divergence is, by then, beginning to differentiate the core, where the next tech-

nological revolution has irrupted, and its elements are being installed. This is soon to annul some of the advances achieved in the periphery.

The earlier manifestations of the phenomenon can be gleaned from the data relating to the first surge, based on the mechanization of cotton in Britain. During the installation period at the end of the eighteenth century, the bulk of cotton production was for home consumption. By 1805, during Synergy, a third of British cotton textiles went to export markets. By 1814 the proportion was approaching a half. As exports continued growing, they went further and further away. In 1820, in the maturity phase of the first surge, 61 per cent of British textiles went to Europe and the USA, and 39 per cent to Spanish America, China, the East Indies, Africa and others. By 1840, when British production had tripled, 71 per cent was already being sold to the periphery.[84] In the meantime, in Europe and the USA great efforts were being made to increase their manufacturing capacity by copying and developing British technology, often with the help of skilled immigrants.[85]

Yet, in the earlier surges, deployment to the periphery, from Maturity onwards, took two main forms: exports and communications. What spread to the periphery were some aspects of the consumption patterns and the infrastructures, such as canals, ports, railways, telegraph, telephone and other modernizing investments that, apart from their own profitability, increased markets for the mature industries of the core, by making medium- or long-distance commerce easier, faster and less costly. They also unwittingly prepared the territory for industrialization.

It is not the object of the present book to analyze what happens in the periphery with each successive technological revolution. For this reason, the discussion has concentrated on the phases of diffusion in the core countries. Great surges, however, are better described as consisting of six, rather than four phases. The first one would be gestation, or the time of preparation for irruption, which is of indefinite duration. Then would come the four being discussed here, which characterize diffusion in the core countries. Finally, the last phase would be the time of stretching and spreading to successive peripheries. In that final period, the last possibilities offered by the prevailing paradigm serve to propagate capitalism across the world. But those two later phases take place in parallel with the first two of the next technological revolution. So each great surge rolls out to the periphery supporting development with the last wealth-producing capacities of its mature technologies, meeting at the end its final defeat (or transformation) by the new paradigm.

The mass-production paradigm is the most recent example. The 1950s was a period of expansion in the USA, which served to pull the front-running

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84. Hobsbawm (1962) pp. 53 and 373.
85. Landes (1969) Ch. 3.

European countries. By the 1960s the main dynamism moved towards Europe and Asia, producing the so-called 'miracles' in Germany, Italy and Japan. In the 1970s, it was Brazil, Taiwan and Korea that had taken over the baton. After the mid-1970s, some of the oil countries were able to attempt growth using the mature energy-intensive technologies in aluminum, petrochemicals and so on. But by then, the information revolution was already taking force in the USA and other core countries and the organizational revolution was catapulting Japan to the front ranks[86] while the stagflation of the irruption phase was entering the scene of the old advanced countries.[87] Soon globalization was defining international market survival. This meant that, in the developing countries, the mature technologies had to be modernized with the new paradigm. By the 1990s, in the casino prosperity of the frenzy phase in the North, joining global firms was made possible by the modernization of mature technologies.[88] This has very much been the case of the North of Mexico, further spurred by the North American Free Trade Association (NAFTA) between the United States, Canada and Mexico, which attracted competitive investment from Japan and Europe to take advantage of Mexican conditions plus easy access to the US market.[89]

Another phenomenon worth analyzing in this respect is the case of peripheral countries leaping ahead and catching up in development during the period of installation in the core, such as Argentina in the 1880s and the 'Asian Tigers' in the 1980s and 1990s. These instances will be discussed in Chapter 10, in relation to the behavior of financial capital in the frenzy phase.

It is important to note, however, that the current surge is likely to be worldwide in character in every phase. Since a key feature of the current Information Age is the establishment of a globalized economy, the spreading of both production and trade networks across core and peripheral countries began from

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86. The fact that the main organizational concepts (such as networks, enriched tasks, flexibility, adaptability and so on), which came together with information technology to conform the presently diffusing paradigm, were developed by the Japanese within the old mass-production technologies is an interesting phenomenon to analyze. A possible explanation lies in the peculiar factor endowment of Japan when catching up using a materials-intensive paradigm (no raw materials, plenty of cheap labor, long-distance to export markets), which stimulated innovation to overcome the limits and use the advantages in a different direction from the USA. See Womack et al. (1990).
87. No such process of relocation and rejuvenation to overcome internal decline and decay was part of the functioning of the overcentralized Soviet system and this lack may have been an important part of the causal chain that led to its collapse.
88. Perez (2001).
89. It is worth noting that outspreading to the periphery will not happen automatically or evenly. Much will depend upon intelligent policies for attracting the technologies and for absorbing them. Whether success in this will actually lead to a leap in development is likely to depend upon the ability of each particular country to use each advance as a platform to innovate and to take advantage of successive windows of opportunity. See Perez (2001).

the early installation period. This feature is likely to distinguish this surge from all previous ones in terms of rhythm of propagation to non-core areas.

So again, and not surprisingly, nothing in the capitalist system is clear and simple. What the model suggests is that the overlapping surges will make the analysis of each period very fuzzy, with some countries experiencing late miracles of synergy with one paradigm while others are already going through the turbulence and tensions provoked by the next technological revolution.