

4. The Propagation of Paradigms: Times of Installation, Times of Deployment

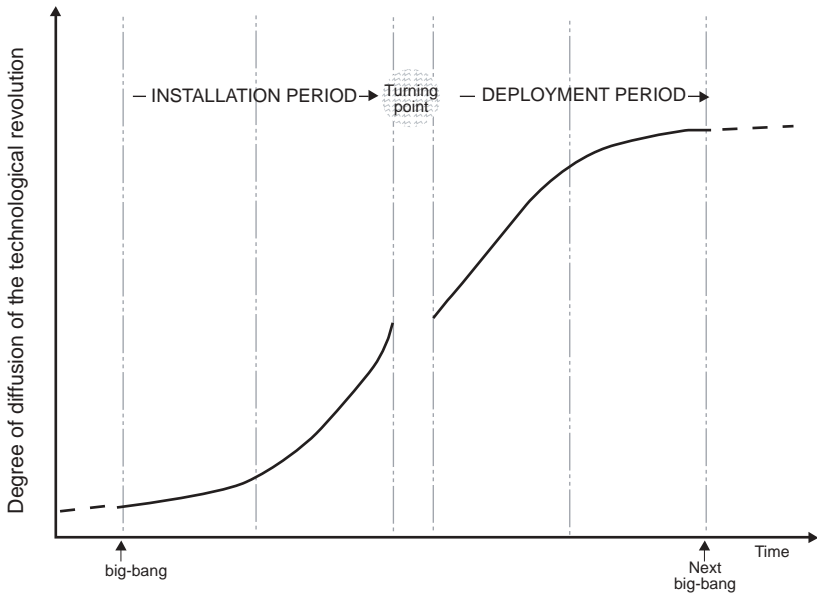
In real life, the trajectory of a technological revolution is not as smooth and continuous as the stylized curve presented in Figure 3.1. The process of installation of each new techno-economic paradigm in society begins with a battle against the power of the old, which is ingrained in the established production structure and embedded in the socio-cultural environment and in the institutional framework. Only when that battle has been practically won can the paradigm really diffuse across the whole economy of the core nations and later across the world. As defined in Chapter 2, the complex processes of propagation of technological revolutions and techno-economic paradigms through the economy and society are the great surges that make development discontinuous.

In very broad terms, each surge goes through two periods of a very different nature, each lasting about three decades. As shown in Figure 4.1, the first half can be termed the *installation period*. It is the time when the new technologies irrupt in a maturing economy and advance like a bulldozer disrupting the established fabric and articulating new industrial networks, setting up new infrastructures and spreading new and superior ways of doing things. At the beginning of that period, the revolution is a small fact and a big promise; at the end, the new paradigm is a significant force, having overcome the resistance of the old paradigm and being ready to serve as propeller of widespread growth.

The second half is the *deployment period*, when the fabric of the whole economy is rewoven and reshaped by the modernizing power of the triumphant paradigm, which then becomes normal best practice, enabling the full unfolding of its wealth generating potential.

The *turning point* from Installation to Deployment is a crucial crossroads, usually a serious recession, involving a recomposition of the whole system, in particular of the regulatory context that enables the resumption of growth and the full fructification of the technological revolution. As will be discussed in Chapters 10 and 11, towards the end of the installation period, there is a phase of frantic investment in the new industries and the infrastructure, stimulated by a stock market boom that usually becomes a bubble that inevitably collapses in one way or another. As represented in Figure 4.1, this frenzy involves an untenable acceleration of the diffusion of the paradigm. The recession creates the conditions for institutional restructuring and for re-routing growth onto a sustainable path.

Figure 4.1 Two different periods in each great surge



This chapter takes a broad look at the interrelated technological, economic and institutional changes involved in the process.

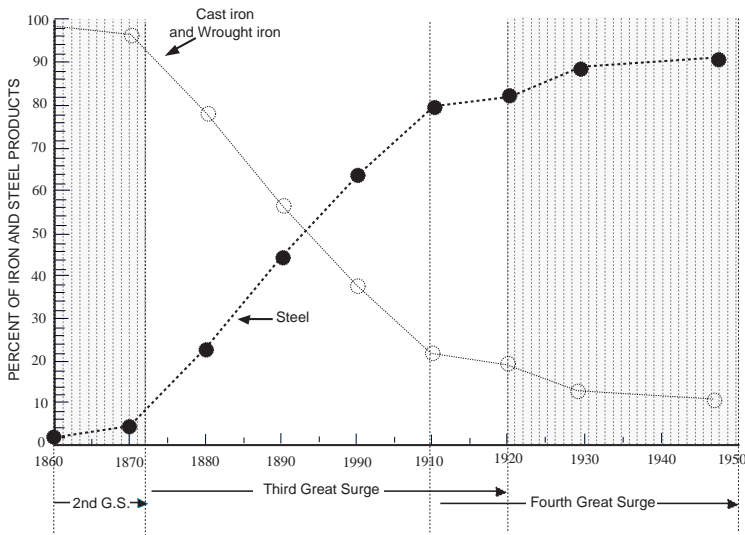
A. Creative Destruction and Social Polarization

Schumpeter's notion of 'creative destruction' aptly portrays the effects of radical innovations. When the core products of a technological revolution start coming together, they inevitably clash with the established environment and the ingrained ways of doing things. Arkwright's water frame was a clear threat to hand spinners both in England and in India. The Liverpool–Manchester railway announced the demise of the horse-drawn carriage for long-distance passenger travel, affecting various occupations from innkeepers to veterinarians.⁵³ The Suez Canal practically eliminated sailing ships from the route to India, while, by cutting travel time from three months to one, it made obsolete the network of huge cargo depots in England, threatening the power of the big

53. Contrary to what one would have expected, the *number* of horses actually *increased* for more than 50 years because of the need for horse transport *from* railway stations to ships, houses, inns and so on. This is similar to the unfulfilled expectations of a paperless office in the wake of the ICT revolution.

trading companies and opening opportunities for smaller ones.⁵⁴ Cheap Bessemer steel was a clear menace to wrought iron producers (see Figure 4.2). The fast, powerful steel steamships with refrigerated cargo opened the world meat and produce markets of the North to competition from the countries of the southern hemisphere. The mass-produced automobile was a clear foreboding of the displacement of steam-powered trains and horse-drawn carriages as the main means of passenger travel.

Figure 4.2 *Steel displacing iron as the main engineering material from the second to the third surge*



Source: Ayres (1989). Surge indications by the author.

Of course, these threats take time to become a reality and resistance from those affected may prolong the transition. But the fact is that once a truly superior technology is available, with higher productivity and clear growth potential, the outcome in the medium term is practically inevitable. This is all the more so, given that, as suggested above, these revolutionary developments generally occur when the profitable investment opportunities attached to the previous paradigm are nearly exhausted.

What these big-bangs inaugurate is a new direction and a powerful attractor for investment. Successful radical innovations receive and promise extraordinary profits in a sluggish mature industrial landscape. The new products and

54. Wells (1889:1893) p. 32.

infrastructures experience amazing rates of growth. Soon, the new generic technologies and the organizational innovations that accompany them allow other products and industries to join the bandwagon through modernization. This new lease of life is particularly welcome by the still powerful firms in the core industries of the previous revolution, which are likely to be facing serious paradigm constriction by this time. Railways changed to steel rails and improved steel engines as soon as they were able in the 1870s and 1880s. The maturing automobile industry in the 1970s and 1980s incorporated electronic chips in vehicles, computer-controlled production equipment and the flexible organization model, first developed by the Japanese. In general, it was the mature giant corporations in the 1960s and 1970s that tried to increase administrative control and white-collar productivity by trying out the early computers and minicomputers.

Thus, the irruption of the technological revolution also signals a cleavage in the fabric of the economy along several lines of tension:

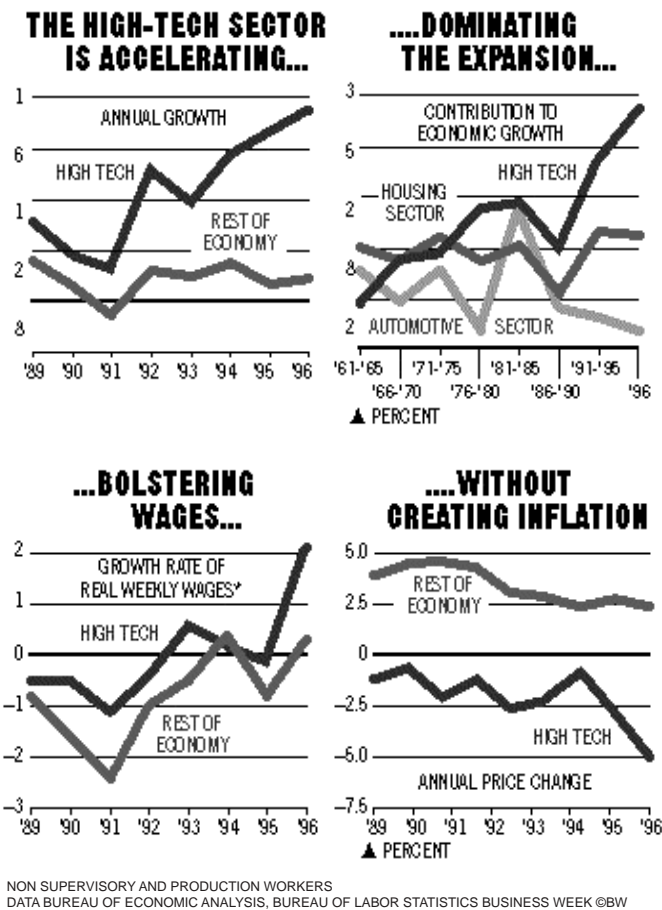
- between the new industries and the mature ones;
- between the modern firms – whether new or upgraded by the new methods – and the firms that stay attached to the old ways;
- regionally, between the strongholds of the now old industries and the new spaces occupied or favored by the new industries;
- in capabilities, between those that are trained to participate in the new technologies and those whose skills become increasingly obsolete;
- in the working population, between those that work in the modern firms or live in the dynamic regions and those that remain in the stagnant ones and are threatened with unemployment or uncertain incomes;
- structurally, between the thriving new industries and the old regulatory system, and
- internationally, between the fortunes of those countries that ride the wave of the new technologies and those that are left behind.

These polarizing trends worsen as the firms wedded to the previous paradigm increasingly confront exhaustion, in the form of depleted innovative trajectories, diminishing profits and stagnation of productivity and markets, while the new ones display extraordinary profits, growing productivity and rapid market penetration. Depending on the institutional and macroeconomic framework of the particular period, the declining industries face either deflation or inflation in their constricted markets.⁵⁵ The regions where they predominate

55. Those economists who believe the economic sphere to be self-contained will probably cringe at the thought that the same fundamental cause can lead to deflation in a period of unrestrained markets, such as the 1870s and 1880s, and to inflation in economies shaped by oligopolies and state intervention such as those of the twentieth century.

will decline; their labor force will face growing unemployment. The contrast between the dynamism of modern firms and the sluggishness and deterioration of the laggards ends up translated into a polarized income distribution. Worse still, when changes are made that suit the flourishing of the new technologies, the situation for those not modernized becomes even more difficult. Figure 4.3 shows how *Business Week* saw the US economy gradually decoupling from the late 1980s to the mid-1990s, differentiating the 'high-tech' sector, belonging to the so-called information economy, from the rest.

Figure 4.3 Decoupling of the system: the differing performance of the 'high-tech' sector and the rest of the economy in the USA, 1989–96



Source: Mandel (1997) Reprinted from the March 31, 1997 issue of *Business Week*, Latin American Edition, by special permission, copyright © 1997 by McGraw-Hill.

These diverging fortunes are reflected in the stock market where, as will be discussed in Part II, a bubble tends to develop around the new technology firms and their associated new infrastructure.

Gradually, as the rich and the successful get richer and more successful, while the poor or weak get poorer and weaker, the legitimacy of the established political regimes comes increasingly under question and pressures for reversing the centrifugal trends become stronger and clearer. Hence, the first two or three decades of creative destruction after the big-bang are increasingly turbulent and the benefits of growth are very unevenly distributed. As mentioned above, the protests that are likely to develop can take highly different specific forms, from the explosive social revolts of 1848 in the early days of industrialization in Europe to the transnationally organized demonstrations against globalization in Seattle, Genoa and elsewhere. The political responses also vary enormously, depending on the particular historical context. Similarly desperate social conditions facilitated Hitler's rise to power in Germany and inspired Roosevelt's New Deal in the United States in the 1930s.

B. Installation and Deployment Periods: Decoupling and Recoupling of the Economy and Institutions

To accommodate each technological revolution, then, many changes need to occur at different levels. In the first place, the new technologies will require the establishment of a whole network of interconnected services such as the specific infrastructure and the specialized suppliers, distribution channels, maintenance capabilities and others that provide the territorial externalities to facilitate diffusion. Without roads, gasoline stations and mechanics, people cannot use automobiles, yet only enough automobiles on the road will make it profitable to run a station or a garage. So diffusion occurs through intricate feedback loops.

Then, there is the cultural adaptation to the logic of the technologies involved. A vast learning process must take place among engineers, managers, sales and service people and obviously consumers, about the production and use of the new products. This not only supposes learning to drive a car, use a radio or a washing machine, but also an understanding of the direction of innovation, so that novelties can easily be adopted and accepted. The progression from desktop to laptop to palm top is gradually understood as the 'normal' sequence of change both in production and in consumption. Adaptation also involves acquiring the organizational notions embodied in the corresponding paradigm. These begin transforming the enterprise and gradually spread out to more and more non-economic activities.

Finally there is the wider set of institutional enablers, involving rules and regulations, specialized training and education, standards, supervisory bodies, financial innovations and so on. The traffic code and consumer credit for monthly payment of automobiles and electrical appliances were equally necessary for the growth of the respective markets of the fourth surge.

Of course this adaptation is not passive. The specific ways in which a society transforms the context to assimilate a technological potential will, in turn, shape the direction the technologies will take and the intensity of their diffusion. An extreme case of these variations was seen with the Western democracies and the Soviet system, which both adopted mass production, the automobile, Taylorism, mass electrification, synthetics and most of the other technologies associated with the fourth technological revolution, but the resulting lifestyles and production profiles were very different.

However similar or varied, the process of social assimilation of a technological revolution shapes and adapts the environment and the economy so that, when it is done, there is near complete coherence between all spheres of society. It becomes the reign of a particular paradigm to the point where it is believed to be universal common sense and becomes unconscious and invisible.

At this point, it is important to note that this process of deep adoption of a paradigm, though tending to inhibit truly revolutionary change outside the scope of the particular technological revolution being deployed, facilitates the full diffusion of each surge. By this inclusion–exclusion mechanism, the system permits reaping the full fruits of the vast investment made in infrastructure, equipment, technological development, training, experience and social learning associated with that paradigm. All this economic and social effort becomes a set of externalities for further investment and wealth creation based on market expansion and compatible innovations. Thus there is a virtuous cycle of self-reinforcement for the widest possible use and diffusion of the available potential. It is when signs of exhaustion appear that the terrain is ready for its replacement.

When the economy is shaken again by a powerful set of new opportunities with the emergence of the next technological revolution, society is still strongly wedded to the old paradigm and its institutional framework. The world of computers, flexible production and the Internet has a different logic and different requirements from those that facilitated the spread of the automobile, synthetic materials, mass production and the highway network. Suddenly, in relation to the new technologies, the old habits and regulations become obstacles, the old services and infrastructures are found wanting, the old organizations and institutions are inadequate. A new context must be created; a new ‘common sense’ must emerge and propagate.

This means that a painful and difficult process of learning and adaptation must take place, involving creative destruction across all spheres. It also explains why the fruits of that new growth potential cannot be fully reaped in the

first decades, when the accommodation and mutual shaping of society and the new economy occur, pushed by the profit motive in spite of institutional inertia and human resistance.

Hence, increasing polarization and decoupling both inside the economy and between the new economy and the old social framework characterize the initial diffusion of a technological revolution. So, the installation period is one of tense coexistence of two paradigms, one declining and the other occupying more and more space on the ground, in the market and in the minds of people. These diverging processes are bound to shake, challenge and change the institutional environment. These spells of turbulent structural transformation have historically lasted from 20 to 30 years, beginning with the big-bang of the revolution and usually coming to an abrupt end with a crash or a panic. As will be discussed in Part II, the advent of a technological revolution attracts financial capital by enormously raising profit expectations, which eventually lead to asset inflation and a financial bubble that ends in collapse.

This financial frenzy is a powerful force in propagating the technological revolution, in particular its infrastructure, and enhancing – even exaggerating – the superiority of the new products, industries and generic technologies. The ostentation of success pushes the logic of the new paradigm to the fore and makes it into the contemporary ideal of vitality and dynamism. It also contributes to institutional change, at least concerning the ‘destruction’ half of creative destruction.

At the same time, as mentioned before, all this excitement divides society, widening the gap between rich and poor and making it less and less tenable in social terms. The economy also becomes unsustainable, due to the appearance of two growing imbalances. One is the mismatch between the profile of demand and that of potential supply. The very process by which intense investment was made possible by concentrating income at the upper end of the spectrum becomes an obstacle for the expansion of production of any particular product and for the attainment of full economies of scale. The other is the rift between paper values and real values. So the system is structurally unstable and cannot grow indefinitely along that path.

With the collapse comes recession – sometimes depression – bringing financial capital back to reality. This, together with mounting social pressure, creates the conditions for institutional restructuring. In this atmosphere of urgency many of the social innovations, which gradually emerged during the period of installation, are likely to be brought together with new regulation in the financial and other spheres, to create a favorable context for recoupling and full unfolding of the growth potential. This crucial recomposition happens at the *turning point* which leaves behind the turbulent times of installation and paradigm transition to enter the ‘golden age’ that can follow, depending on the institutional and social choices made.

The following two or three decades, characterized by the generalization of the now triumphant new paradigm, constitute the *deployment period*. When it arrives, the surge of development, based on the full diffusion of the higher levels of productivity, becomes clearly visible across the whole economy. The new common sense embraces all activities, from business, through regulation and education, to government. As a result, an era of general ‘good feeling’ sets in, characterized by increasing coherence within the economy. The institutional set-up that enables full deployment includes means of expanding demand to accommodate the enormous potential of increase in production, already installed. This can occur in many ways and has tended to involve the spreading of the benefits of growth to successive layers of the population.

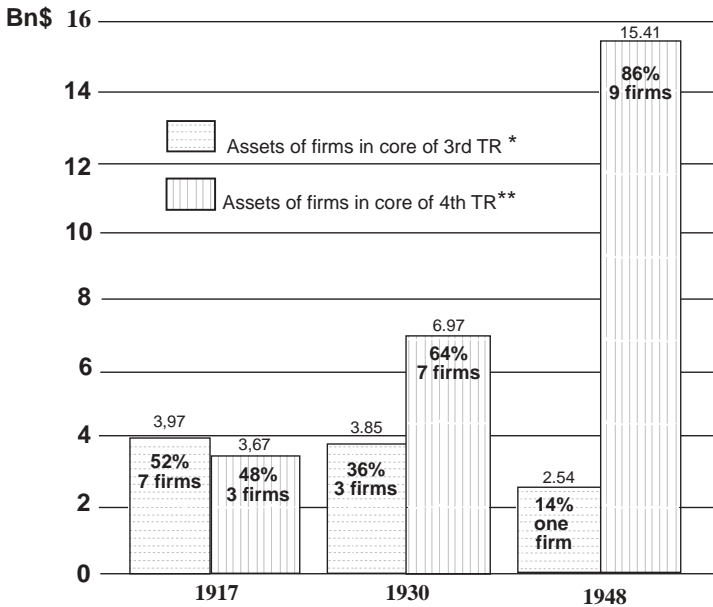
By this time the original industries of the technological revolution have become the engines of growth for the whole economy and the country where they developed stands at the core of the world system. Together, these industries represent a significant portion of the national product of that core and the main firms have usually by then become the largest in that country and probably in the world. Figure 4.4 uses Chandler’s data on the ten largest US corporations by asset size,⁵⁶ from 1917 to 1948, to illustrate the shift of power from the third to the fourth surge. Steel continues to be extremely important for the automobile and other products of the fourth technological revolution but the real investment boom is in the latter and they soon far outpace the steel companies and crowd them out from the top.

Furthermore, during the period of deployment, a process of internal catching up takes place within the economy. The dynamic pioneers of the revolution slow down, from sheer size, while those now joining the paradigm bandwagon accelerate. It is a question of relative weights and rates. The new industries that had developed explosively in the installation period are now giants growing at a ‘normal’ rhythm, whereas later industries, products and systems within the revolution – or those modernized or induced by it – may be reaching the same or faster rates of productivity increase and market growth. So employment rises steadily and, depending on the institutional framework set up, there can be a shared feeling of pending improvement in the general quality of life, very different from the centrifugal fortunes of the installation period.

Nevertheless, as these times of prosperity wear on, the potential of the technological revolution is gradually depleted. Technological maturity and saturation of markets begin to restrain the growth of productivity and production in the core industries, while widespread market and production experience shorten

56. No attempt is made to turn current values to constant ones for two reasons. First, the object is to see relative proportions at each point in time and this can be done well in current values. Second, the period spanned is one of great economic turbulence including also the depression and a major war at each end, so all attempts at standardizing would be both heroic and doubtful.

Figure 4.4 Oil and automobile industries replacing steel as engines of growth from the third to the fourth surge



The top 10 US firms by asset size in 1917, 1930 and 1948, grouped by technological revolution (TR)

Notes: * Steel and meatpacking.
 ** Oil, automobiles, agricultural machinery, organic chemicals and electrical appliances.

Source: Our classification of data in Chandler (1990) pp. 639–57

the life cycles of the later products. This increasing constriction reduces the capacity of the system to fulfill its promises of constant progress, though the signs of an affluent society are still strong and visible. This, in turn, leads to labor and political unrest. Historically, some of the major strike waves have taken place towards the end of the deployment period.

A historian of the British Trade Union Movement refers to such final periods of the second and third surges thus:

The late 1860s and early 1870s were, indeed, exciting years for the trade unions. The Trades Union Congress was effectively formed ... in 1868. The Amalgamated Society of Engineers⁵⁷ struck for the nine-hour day ... and the Yorkshire miners

57. At that time the term ‘Engineers’ referred to qualified engine drivers, mainly in railways.

became particularly aggressive in their demand for wage increases ...⁵⁸

Industrial conflict began to increase dramatically on the eve of the First World War ... Improved economic conditions encouraged trade unions to attempt to win back the wage reductions they had suffered in the previous decade ...⁵⁹

So what begins promising a golden age ends up in economic trouble and intense political confrontation. Both will contribute to the coming together of the next technological revolution and the cycle will begin all over again in another unique and specific manner.

58. Laybourn (1991) p. 53.

59. Laybourn (1991) p.104. As Hobsbawm remarks, the '*belle époque*' in most of Europe incorporated the middle classes into prosperity but did not reach the working classes Hobsbawm (1987:1989) p. 55. This is consistent with the observation made in section 5F above that the whole of the third surge in Britain had some features of a maturity phase.