From long waves to great surges: continuing in the direction of Chris Freeman's 1997 lecture on Schumpeter's *Business Cycles*

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By the time Chris Freeman was preparing his La Tuscia lecture in the late 1990s, the impact of ICT was already massive and the use of the term ‘revolution’ to refer to it had become commonplace. The need to follow Schumpeter's lead in reaching a deeper understanding of technological revolutions and their relationship to business cycles seemed crucial; all the more so as we suspected that the key to economic upswings and downswings was the shift from mismatch to match between each revolution and the socio-institutional framework. Confirming this would have important policy implications.

A few years later the results of our efforts appeared in print: *As Time Goes By: From the Industrial Revolutions to the Information Revolution* (Freeman and Louça 2001; henceforth referred to as ATGB) and *Technological Revolutions and Financial Capital: the Dynamics of Bubbles and Golden Ages* (Perez 2002; referred to as TRFC). Both books continued in the direction that Chris had signaled at the end of his lecture: namely, "overcoming some of the weaknesses in Schumpeter's pioneering formulation" as being "the best tribute to the spirit of his work".

The present note follows in that direction. It will discuss why putting the accent on the diffusion and social assimilation of each technological revolution, rather than on the fluctuations in GDP, leads to a different focus of analysis and a different dating. Most importantly, it helps in the use of history as a source of insights for acting in the present.

From individual innovations and systems to technological revolutions

One of the main shortcomings that Freeman identifies (above pp. 51-52) in Schumpeter's *Business Cycles* (1939; from now on BC) is the use of an a-historical theory of entrepreneurship in place of theories of the firm and of technical change. Filling that gap has been the goal of the Neo-Schumpeterians in evolutionary economics and innovation studies. Indeed, thanks to the pioneering work done by Chris in *Economics of Industrial Innovation* (1974), by Nelson and Winter in *An Evolutionary Theory of Economic Change* (1982), and

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by their many followers, we can now rely on a solid account of the relationship between technical change and the firm, of that of technology and the economy, and of the nature of systems of innovation, technological trajectories and technology systems as well as numerous other aspects that provide substance to Schumpeter's fundamental claim that growth is driven by innovation.

All those advances were crucial for approaching the wider theme of technological revolutions --as a system of technology systems-- and of the relationship between such major upheavals in the economy and the roles played by finance and government policy in the direction they take, as well as the consequences for society. A hundred years after Schumpeter's *Theory of Economic Development* (1911), researchers could now work, not only with Schumpeter's own advances from the 1930s, but also with bountiful historical accounts and more reliable statistics. In ATGB, their major work on technological revolutions, Freeman and Louçã present a profound discussion of the theoretical case for long waves, their relationship with technological innovation and their multi-factor nature together with an analytic description of each of the five technological revolutions that drove them.

Part One is a thorough methodological discussion of the approaches to explaining economic growth. They begin by questioning the validity of econometric history (or cliometrics) as a way of expunging real history and the crucial qualitative elements from the analysis. They then follow Schumpeter in his paradoxical defense of market equilibrium and econometrics while doing in fact reasoned history, based on the real technologies that underlay the cycles he studied. They follow with a critical examination of the work of Nikolai Kondratiev and conclude in agreement with both authors as to long term fluctuations or waves being in the nature of the capitalist economy. Having questioned the validity of pure quantitative analyses they proceed to argue the case for 'reasoned history' defined as "an approach to economic history including technological innovations, structural changes, and the co-evolution of economic and social movements within the framework of institutional settings and modes of regulation" (p. 123).

Since the early 1990s, Chris had been working on a theory of economic growth as the result of the co-evolution of "five historical processes or sub-systems of society: ... science, technology, economy, politics and general culture" (Freeman 1995). He defined them as sub-systems with their own selective mechanisms, each with "its own distinctive features and relative autonomy". He saw their interdependence and mutual influence as the source of "major insights into the processes of 'forging ahead', 'catching up' and 'falling behind' in economic growth." His argument was that "positive congruence and interaction between them provides the most fertile soil for growth, while lack of congruence may prevent growth altogether, or slow it down." That was indeed a much wider program than that implicit in the original Schumpeterian examination of the sources of economic growth and of its deviations from equilibrium

He wrote it as a working paper for IIASA (1995) but never polished it for publication. In fact, Chris had added a footnote saying that "the inordinate length is due to the fact that, if it survives at all, it is destined to become two or three related papers, or possibly a couple of chapters in a book".

His objective was fulfilled in collaboration with Francisco Louçã in ATGB, where Part Two is a wide-ranging analysis of each of the five technological revolutions (pp. 135-335) examining the historical record, taking into account the evolution, behaviors and interactions of the five overlapping subsystems. In essence, the work of Freeman and Louçã demonstrated the possibility of handling, in a powerful explanatory manner, the complex mixture of recurrent and unique phenomena that characterize the evolution of capitalism.

Abandoning 'Kondratiev long waves' for 'great surges'

Following their lead, my own research (2002, 2009 and 2010) examined the regularities in the role of finance and government in the diffusion of innovations and in the patterns of growth. In order to do so, I increasingly faced the need to analyze the processes of propagation of the specific technologies involved and of assimilation of their techno-economic paradigm across society. However, this soon deepened our doubts as to the validity of the upswing-downswing view of long waves and of Schumpeter's dating, which we had already modified in a joint article (Freeman-Perez 1988) by including long overlaps.

Notably, the idea that the 1920s were part of the downswing of the third long wave was disturbing. True, a two-year recession followed WWI, and the1930s brought the 'Great Depression', but considering the 'Roaring Twenties' as part of a downswing did not seem fit. Not only was this era – at least in the United States – a time of financial boom and high growth, but it witnessed the development and early diffusion of most of the technologies that underlay the post-WWII boom. Chris Freeman was very conscious of this, so much so that the ATGB chapter on the fourth Kondratiev wave begins with two pages (257-8) explaining why it includes the "downswing" of the third (i.e. the 1920s and 1930s) together with the analysis of the upswing of the fourth. In fact, already in that section, he advances what amounts to a redefinition of the downswing as "a period of structural adjustment to the very rapid rise of a new constellation of technologies" (p. 257). This clearly revealed the discomfort with Schumpeter's dating which was increasingly part of our discussions. Gradually I became convinced that it had to be boldly revisited.

By setting aside the GDP figures and concentrating instead on the diffusion of the sets of interrelated new technologies, a different picture emerged. There had indeed been five technological revolutions – but they did not coincide with the Schumpeterian dating. The diffusion of the revolutionary technologies took the S-shape of a typical technological trajectory (Nelson and Winter 1977), from initial slow introduction to a take-off that leads to an intense and dynamic period of multiple innovations, until maturity and exhaustion are reached and innovation in that system slows down. Yet, in each case, rather than a continued prosperity in that dynamic mid-range, the economy experienced first a mania or bubble, which then collapsed in a panic and led to a recession of shorter or longer duration. It is after that breakdown and its consequences that a full-blown prosperity grounded in the potential of those new technologies takes place. While indeed coinciding with a succession of major transformations in capitalist development, this pattern did not fit with fifty year cycles of upswing and downswing in growth rates.[2] Thus the terms 'long cycles' and 'Kondratiev long waves' were inadequate. The choice of 'great surges of development' in their stead was intended to emphasize the leap in productivity brought by each technological revolution, and the capacity of each techno-economic paradigm to lift, rejuvenate and transform the whole economy and society along with it (Perez 2002 pp. 20-31, 60-62).

The research consequences of the shift of focus

In the second volume of his *Business Cycles* (1939), Schumpeter engages in the gigantic task of identifying the technologies and industries that underlay each minor, medium or major

[2] It is important to note that, when working on the waves in detail in BC, Schumpeter somewhat distanced himself from Kondratiev's (1925) straightforward upswing-downswing view and worked on a curve that began rising at equilibrium with *prosperity*, then descended in *recession,* continued down (crossing the equilibrium path) into d*epression* and finally returned to equilibrium in *revival*. This separation of the good times into revival of one wave and prosperity of the next is an interesting aspect, well worth a serious discussion that cannot be properly undertaken here.

boom (the Kitchin, Juglar and Kondratiev cycles) in the UK, US and other countries. Given the insufficiency of statistics and of industrial information, it was a titanic undertaking. As Freeman reminds us (p. 49 above), Schumpeter acknowledged that the aggregate statistical series did not reveal – and often concealed – all the changes that were taking place. In fact, in BC (p. 484), he went as far as saying that the concept of 'total output is a figment' and 'a meaningless heap'.

For that reason, Schumpeter insisted on disaggregating statistics and looking at the specific industries and clusters of innovation behind each boom. His results are therefore of great value for the sort of effort that we had to do when looking at the process of technical change from the ground up. That is part of what Freeman and Louçã (ATGB) do in chapters 5 to 9 covering each of the five technological revolutions and it is some of what my tables 2.1, 2.2 and 2.3 summarize in TRFC.

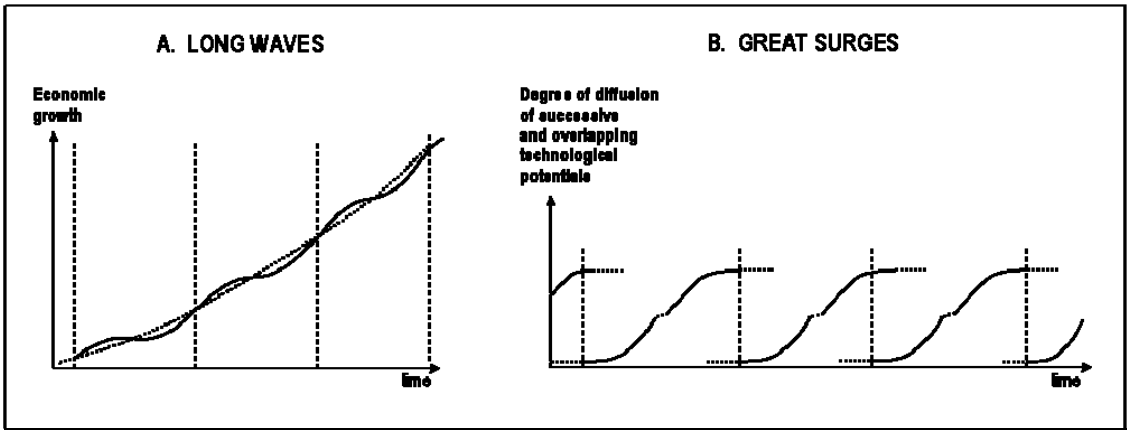
The change of conceptualization from long waves in economic growth to great surges of technical change moves the researcher from focusing on the quantitative and formal to the qualitative realm of "appreciative theorizing" (Nelson and Winter 1982 pp. 45-48) and "reasoned history" (ATGB pp.117-18 and 124-30). The method now turns to using the work of multiple historians and contemporary media in search for patterns of recurrence that could have causal explanations. The economic growth figures are simply one of the areas to be examined from the point of view of their mutual relationship with technical change.

Figure 1 presents the differences in approach and the contrasting nature of the representations. Long waves can be the object of statistical testing with long term series. Great surges are a historical narrative, requiring the concrete identification of the various technology systems interconnected by each revolution and the observation (qualitative and quantitative) of both their spread across the production system and the influence of the resulting paradigm across society.

Naturally, that shift of focus from growth to technological diffusion changes the y-axis and the shape of the phenomenon being studied. Since Schumpeter's long waves assume an equilibrium path of growth with upward and downward deviations, the implicit y-axis is GDP. By contrast, great surges are about the rhythm and path of assimilation of each technological revolution and its paradigm, so the vertical axis represents the level of diffusion of its potential across the economy.

Figure 1

Two different ways of looking at technology and the economy



Two important features should be noted in the graphic representation of the great surges: one is the long overlap between successive surges at the beginning and the end; the other is the break in the middle, representing a bubble collapse (such as the canal and railway panics and the crash of 1929) which stops the frenzy of investment and slows down the diffusion of the installed technological potential until more favorable conditions are created to enable the second take-off. But the periods before and after the major bubble are part of the same revolution, though with different characteristics.

Indeed, in ATGB, Freeman and Louça hold that the diffusion of each revolution may last more than a century. They distinguish six phases, from the original practical or scientific roots to the final survival of some of its aspects beyond maturity. What can be considered the 'revolution' proper, with major influence on the economy and society, would be phases two to five (p.146), from the time when the new technologies begin to clearly replace the old until they themselves begin to be displaced by the next revolution.

Implicit assumptions are (1) that the revolutions are unique enough to be distinguished from one another; and (2) that there are recurrent phenomena, present in every surge, with identifiable causes in the process of assimilation. This allows the researcher to conduct the analysis surge-by-surge and shift-by-shift looking at the recurring features; while the common characteristics of each set of technologies -- conceptualized as techno-economic paradigms (Perez 1985) -- become one of the main elements of differentiation between surges. Indeed, one of the key conclusions in ATGB was the need to recognize that the regularities are only meaningful when they are seen in their unique context (pp. 130-134).

Re-examining the historical record

Once the set of technologies that constitute each revolutionary surge has been roughly identified through 'reasoned history', it is possible to engage in critical historical investigation to strengthen or question the expected patterns of recurrence (ATGB pp. 139-151). Research into the occurrence of similar phenomena in technological, economic and socio-institutional behaviors can be made both within the period covered by each surge and in the transition from one to the next. In the La Tuscia lecture, Freeman looks at the decreasing prices of the successive key factors (coal, steel, oil, microelectronic chips); in ATGB, the recurring regularities in phenomena as diverse as the frequency of strikes, the recurrence of periods of extraordinary profits and the changing international regimes of regulation were observed (pp. 340-370).

Further examination of the evidence suggested a recurring shift of roles between financial and production capital (TRFC Ch. 1 and 8). As represented in the figures above, each great surge brings two different prosperities. The early decades of revolution lead to a financial frenzy or mania – a bubble prosperity. The inevitable panic is followed by a recession of different duration. But after each frenzy of investment, there is enough technological potential installed for the paradigm of the new revolution to transform the entire economy into a ‘golden age’ prosperity (TRFC, Ch. 5). Eventually the set of technologies underlying each golden age reaches exhaustion, productivity gains diminish, markets become saturated, a recession ensues and the conditions are there for the next revolution to come together[3] from the many technologies that have been in gestation at the margins of the prevailing paradigm (sometimes going back much further in time).

[3] The reasons why market economies tend to generate technical change by successive revolutions is a crucial part of the uneven growth puzzle. The role of techno-economic paradigms and financial capital in the process is discussed in TRFC (pp. 27-32).

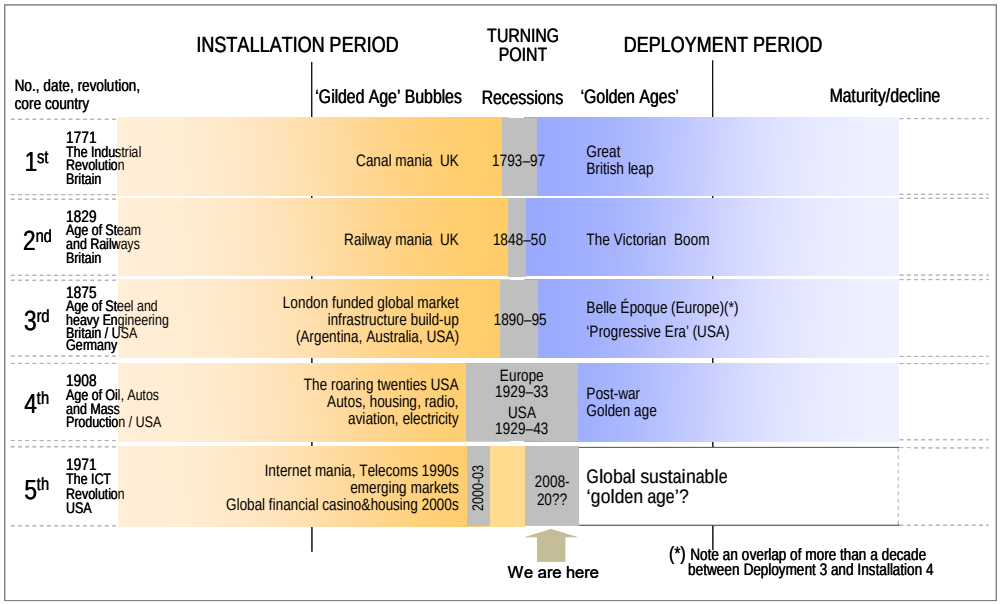
Figure 2 presents the five surges in parallel indicating the recurring sequence from what can be called the techno-economic big-bang in the core country to maturity. The two distinct prosperities on either side of the post-panic recession can be roughly identified with terms used by contemporaries.

Yet the dating is inevitably fuzzy. One of the few dates that can be pinpointed is precisely the bubble collapse, although in the current ICT surge there have been two major collapses already, and in the third surge there were several, most of them in the peripheral world. The ensuing recessions have been of very different durations – from as little as two years to as much as thirteen – and the end of each surge is a drawn out process of replacement, modernization and redefinition of one industry after another under the influence of the emerging paradigm.

It is also possible to recognize the core country where each revolution begins, and to suggest a date for the 'big bang' – an innovation so impressive that it signals the opening of a whole universe of creativity and extraordinary profits (TRFC pp. 10-12). Arkwright's mill can be seen as heralding the first, the Rocket engine of the Liverpool Manchester railway the second and Carnegie's Bessemer steel plant the third; Ford's Model-T initiated the fourth and Intel's microprocessor signaled the fifth.

Figure 2

Five great surges and their recurring sequence: bubble prosperities, recessions and golden ages



Based on Perez 2002 and 2009

The regularities are more in the type of process than in the dates or durations. Surges have lasted from less than forty to more than 60 years (if we count from big-bang to big bang or from crash to crash) and equivalent variation is seen in installation and deployment periods. The type of process is also expressed in different ways. The first half of each surge is characterized by financialization and the forced modernization of the old industries and technologies with the new paradigm, in what tends to be unfettered competition. Yet, in one surge, it can be limited to the national and local space, as in canal mania in the 1790s, and in

another be a globalized process, as in the third surge in the 1880s-90s and in the current one. The second half of the surge is what is seen as the Golden Age prosperity, with growth, expansion, increase in the wellbeing of greater proportions of the population and the leadership of production capital with clear support from government. But again, while the second surge saw the rise of the industrial, commercial and professional elites, as manufacturing and trade brought a high urban standard of living (different from the aristocracy's), during the fourth, it was the working classes of the advanced world that rose to become 'middle income consumers', incorporated into suburban living, an essential part of the 'American way of life'.

Yet, for all the uniqueness of each revolution, of each paradigm and of each period of each surge, the regularities are powerful enough and, since they can be related to causal mechanisms, are able to serve as guidance for the action of all agents, be they companies, social movements, governments or others.

Patterns of recurrence and policy implications

As Chris discusses in his lecture, Schumpeter had unmovable faith in the virtues of the unfettered market to maintain the basic equilibrium trend while deviating, either up or down, with the forces unleashed by innovation. For him, society and politics were basically out of the explanatory picture (though deeply affected), whereas for us they are an essential part of the explanation. Schumpeter believed governments should stay out of the economy except in extraordinarily depressive circumstances; for us, they play a central role, in particular in counteracting the devastating effects of the bubble processes, which lead each time to unemployment and income inequality, deterioration of erstwhile prosperous regions, social unrest and upheaval – and, crucially, lack of investment in the real economy.

Indeed, an examination of the historical record (ATGB pp 336-370 and TRFC Ch. 13 and 163-166) reveals regular changes in the socio-institutional framework with each technological revolution. Those different regulatory regimes, for the deployment of each technological revolution, have shaped the conditions under which markets operate, and consequently defined the most profitable direction for innovation and investment. These conditions are the ones that have led to Golden Ages.

It is in this sense that making well-founded historical parallels can help policy makers. If we are indeed in times similar to the 1930s – post-bubble collapse, mid-way along diffusion, still in the clutches of finance rather than production – then, instead of trying to return to the unfettered market conditions that brought the bubble, what is in order is to apply steering and shaping policies such as the Keynesian ones that unleashed the post-WWII boom. But, that's as far as recurrence can go.

As discussed above, and as Freeman and Louçã emphasized, the uniqueness of each paradigm provides a different potential, requiring a different way of exercising the same type of process – that of giving direction to innovation and investment in order to generate synergies for business and the most beneficial outcome for the majorities in society. It is locating that direction in order to achieve congruence that is the task now for social scientists, policy makers and political leaders; for the Keyneses, the Beveridges and the Roosevelts of this surge.

The task is one of maximum creativity, imagination and value-driven determination. What technology offers is a specific wealth creating potential that is recognizable in its range and that can be shaped in many optional directions. It merely provides the space where social conflicts and compromises about the future are to be staged. What the great surges model offers leaders and policy makers is a set of heuristics to understand the way the market

system generates and assimilates technical change, how technology changes development opportunities and how government and society shape and steer the potential inherent in those opportunities.

At the end of the epilogue of ATGB, Freeman and Louçã propose an interesting view of the purpose of their discipline: 'Unable to predict the future, economics is about our apprenticeship with the past, which matters primarily because this understanding helps us to act in the present and in the future' (p. 372). Continuing in that intensive apprenticeship is the best tribute we can pay to Chris Freeman and the best use of the inspiration he gave us.

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