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TECHNOLOGY AND SOCIO-ECONOMIC DEVELOPMENT IN THE LONG RUN

A ‘long wave’ perspective

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Introduction

The dynamics of economic life is not of a simple and linear but of a complex nature, Nikolai Kondratieff noted when he detected that economic development in capitalist economies is characterized by ‘long waves’ of approximately fifty years’ length. His suggestion that these waves are likely to be linked to technological change was taken up by Joseph Schumpeter who endogenized technical change in a theory of economic development. Neo-Schumpeterian economists refined this idea, many of them emphasizing the key role of institutional change for innovation and diffusion of new technologies that drive the dynamics of the long wave. Each wave is historically unique and driven by the diffusion of specific clusters of technologies, and the related political and institutional change has shaped socio-economic development in each individual historical epoch differently. The dynamics of long waves, however, is characterized by patterns and regularities of how technologies are diffused, and how and under what conditions this process brings about fundamental change in the economy. Thus, there is the question of how this relates with government policies – be it to induce techno-scientific progress as a basis for new technologies or be it how to adapt to the newly emerging technologies and the related organizational change.

Technological change and economic development: Early long-wave contributions

In econometric analyses of long time series Kondratieff (1926, 1935) and van Gelderen (1913, 1996) independently claimed to having detected wave-like movements of an average length of approximately fifty years. Each ‘long wave’ marks a distinct historical epoch comprising a long-term upswing and a long-term downswing of economic activity (Kondratieff) or a ‘spring tide’ and an ‘ebb tide’ (van Gelderen). Both authors suggest a close link between technological change and the long wave. Kondratieff claimed to merely describe the phenomenon of long waves;
the direction and intensity of technical change would be determined by ‘the necessities of real life’, and by the preceding development of science and technique (Kondratieff 1935: 112). An exceptionally large number of important discoveries and inventions in the technique of production and communication would emerge in recessions, which would be applied on a large scale only in the following long upswing (Kondratieff 1935). In Kondratieff’s understanding the introduction and diffusion of new technologies are not drivers of the long wave but are driven by the long wave. By contrast, van Gelderen notes that ‘the sudden emergence of a new production branch which, in a more powerful way than before, satisfies a certain human need’, or ‘the cultivation of previously largely uninhibited areas’ (van Gelderen 1996: 40) establish the conditions for the emergence of a period of springtime. Innovation is considered a driver of the long wave, but it is not explained why and how new branches or new markets emerge in order to create the conditions for an expansion of the long wave.

Taking up Kondratieff’s idea of long waves – and actually naming them ‘Kondratieff cycles’ – Schumpeter (1939) developed a framework in which profit-driven entrepreneurs who compare perceived risk and expected returns of new ventures make innovation and technical change endogenous to the economic process. Technological innovation is the driver of at least three types of cyclical economic fluctuations, the forty-month Kitchin cycle, the ten-year Juglar cycle, and the Kondratieff cycle. Radical innovations give way to the formation of new industrial sectors, and incremental innovations based on the initial innovation and imitation lead to a swarming of innovations and trigger the upswing of a long wave. But improvement innovations are subject to the law of diminishing returns and profits are competed-away so that the innovating impulse will dissipate over time.

A brief historical record of long waves

The diffusion of the new technologies that trigger the long wave dynamics is complemented by the build-up of related transport and communication infrastructures and by innovations in the organization of the economy and the management of production. The first Kondratieff or early mechanisation wave occurred during the Industrial Revolution at the turn of the eighteenth to the nineteenth century. Limitations of scale and of process control were inherent to the pre-industrial mode of production and were overcome by mechanization based on the use of water power and factory organization as a major innovation in organizing the production process.

In the second Kondratieff wave the organization of production in terms of location and scale became more flexible through the use of steam power and railways. Limited liability and joint stock companies were major organizational innovations allowing new forms of finance, risk taking and ownership. The first wave was not much felt outside Britain, and the second wave was observed only in a few economically advanced countries (Table 3.1).

The third Kondratieff wave saw the electrification of industry, transport and the home. Steel as a key new input substituted iron as it provided better performance in terms of strength, durability and precision, thus opening new possibilities for metal working industries. Electrification allowed more flexibility in the location of industries and more flexible production organisation at the factory floor. Large firms emerged and management as a profession was established, government policy supported the founding of technical schools in many countries and thus contributed to the development of the required skill base.

The fourth Kondratieff wave was characterized by the large-scale diffusion of mass production to manufacturing industries and later to other economic sectors. Economies of scale could be reaped in firms that operated under oligopolistic competition and became increasingly multinational. The widespread use of automobiles and the adaption of government policies
Table 3.1 Major characteristics of Kondratieff waves

<table>
<thead>
<tr>
<th>Kondratieff waves and their approximate timing of upswing and downswing</th>
<th>Leading countries</th>
<th>Leading branches of the economy</th>
<th>Transport and communication infrastructure</th>
<th>Managerial and organizational characteristics</th>
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</table>
| **Early mechanisation Kondratieff**
up: end of 1780s to 1810–1817
down: 1810–1817 to 1844–1851 | Britain; France, Belgium | Cotton spinning, iron products, water wheels | Canals, turnpike roads, sailing ship | Factory system, entrepreneurs, partnership |
| **Steam power and railway Kondratieff**
up: 1844–1851 to 1870–1875
down: 1870–1875 to 1890–1896 | Britain; France, Belgium, Germany, USA | Railways, railway equipment, steam engines, machine tools | Railways, steam ship, telegraph | Joint stock company, subcontracting to craft workers |
| **Electrical and heavy engineering Kondratieff**
up: 1890–1896 to 1914–1920
down: 1914–1920 to end of 1930s/early 1940s | Germany, USA; Britain, France, Belgium, Switzerland, Netherlands | Electrical equipment, heavy engineering, heavy chemicals, steel | Steel railways, steel ship, telephone | Specialized professional management, giant firms |
| **Fordist mass production Kondratieff**
up: end of 1930s/early 1940s to 1968–1973
down: 1968–1973 to 1987–1992 | USA, Germany; Other EEC, Japan, Switzerland, USSR, other EFTA, Canada, Australia | Automobiles, planes, oil, gas, synthetic materials | Motorways, airports, radio, television | Mass production and consumption, hierarchical organization, oligopolistic competition, multinational firms |
| **Information and communication Kondratieff**
up: 1987–1992 to 2008 (?)
down: 2008 (?) to ?? | USA, Japan, Germany, Sweden; most other OECD countries | Computers, chips, electronic capital goods, software, information services | Information highways (internet) | Networks (internal, local, global), production on demand, individualized mass production |

Sources: Perez (2009); Reati and Toporowski (2009); Freeman and Perez (1988); Goldstein (1988); Kondratieff (1926, 1935).
particularly in the fields of land use, transport and infrastructure changed the location patterns of production, consumption and housing.

The fifth Kondratieff wave, finally, has been triggered by modern information and communication technologies (ICT). The inflexibility of the mass production model to satisfy a diversified demand was overcome by new ICT that allowed the formation of flexible networks within and across firms at a local and global level, production on demand, and finally individualized mass production. The fifth Kondratieff wave also provides an example of the impact of government policies – mostly in the field of research, telecommunications and defence – on the development and diffusion of a new technology triggering the upswing of a long wave. Which technologies will be the drivers of the next long wave remains to be seen; candidates include nanotechnology (see Heinrich and Pfirrmann 2014), biotechnology, new materials, and new energy technologies.

Do long waves exist at all?

The mostly narrative historical account of long waves highlights crucial structural changes and has enriched the understanding of the conditions under which the long wave dynamics unfold. But the ‘obvious inadequacy of these procedures to demonstrate this scheme of historical succession of periods with distinctive social, political, and economic features consequently created strong doubts about the justification for the research itself’ (Freeman and Louçã 2001: 95). Trying to detect the existence of long waves of approximately fifty years’ length in economic time series by using traditional statistical methods or simulation techniques has proved to be a complex undertaking that is still a topic of controversy. Kondratieff already eliminated the trend that is present in some of his time series because of its non-stationary character. But without a convincing assumption about the particular trend form almost any long-period cycle can be produced by using higher-order polynomial trends (Silverberg 2007). A considerable part of research on long waves was devoted to refining econometric techniques. Taking first differences has become a standard method of trend elimination, and structural time series models have been used for testing the existence and synchronization of long waves in GDP series (e.g. Goldstein 1999). Spectral analysis has been frequently used for investigating the existence of long waves in the economy (Ewijk 1982; Haustein and Neuwirth 1982; Metz 1992); recently Korotayev and Tsirel (2010) found waves of fifty-two to fifty-three years’ length in the world GDP for the 1870 to 2007 period, though, possibly, with a shortening of the waves’ length to approximately forty-five years at the end of the period. There is also evidence that upswings of the long waves usually might be somewhat longer than downswings (Coccia 2010).

A shortcoming of econometric methods in the analysis of very long time series is the implicit assumption that no major structural economic changes that could have a disruptive effect on the causality and time structure occur over one or even several cycles stretching over a period of fifty or a hundred or even more years. But as long as wave research postulates such structural changes and tries to explain the drivers of such changes an empirical method that is based on such an assumption seems to be inadequate to the research topic. Further, smoothing or detrending procedures require trend and cycle to be independent which is unlikely if long time series are considered; they may create artefacts with respect to the cycle (Freeman and Louçã 2001: 99). An alternative route to analyse the existence of long waves in economic time series is based on formal models without a direct empirical claim (Forrester 1971) by trying to achieve a good fit of a model’s simulation results with empirically observed time series through tuning model parameters properly. While such models can be useful for the creation of hypotheses in
order to analyse the historical record ‘they are not the reality itself, nor can they reproduce it’ (Freeman and Louçã 2001: 117).

The apparent difficulties of statistical treatment of long waves have led to rather different conclusions for the direction of further research. Silverberg (2007: 814) considers it:

essential that we continue to seek the connection between such models [of long waves] and their expression at the level of statistically testable aggregate time series effects . . . To turn one’s back to this issue is to retreat into metaphysics or relegate long-wave analysis to a sophistic form of . . . historical analysis.

Freeman and Louçã (2001: 116ff), however, suggest an ‘approach of reasoned history’ that combines historical, analytical and descriptive methods. Their approach includes ‘the rejection of the claim for a complete quantitative description of the universe’, giving priority to ‘identification of features of the real time series, instead of the fabrication and simulation from an abstract model’, and to ‘the acceptance of complex determination and the importance of social, institutional, and political factors, represented by semi-autonomous or “hybrid” variables’. Such an approach does not suggest giving up quantitative analysis altogether but recognizing its limitations and supplementing it with qualitative, historical analysis.

**Conceptual requirements of technology-driven long waves**

Even if the existence of long waves in time series of economic indicators could be empirically shown, this could be the result of a regularity observed in the past that need not necessarily be continued into the future or it could be of random causation. Therefore a theoretical foundation is needed to explain the dynamics of economic change in a way that it generates long waves in the economy.

Concerning technological innovation as a causing factor of long waves most authors would accept either implicitly or explicitly the following ideas (Thompson 1990: 203f): major technological innovations are discontinuous in time and space, and the pace of growth differs across economic sectors. They propel economic growth because new leading sectors and new ways of doing things emerge that require considerable investment and extensive infrastructures. The new industrial sectors and new ways to do things are subject to variable mixes of diffusion and imitation, increasing competition and protectionism, market saturation and overcapacity, increasing costs, diminishing marginal returns and institutional rigidities that constrain further growth and innovation.

While acknowledging the role of new technology, some strands of long wave research emphasize other aspects than innovation including the reinvestment process (e.g. Kondratieff 1928; Forrester 1981), fluctuations in the prices of primary commodities (e.g. Rostow 1978; Modelski 1982), war as a driver of long waves (e.g. Kondratieff 1926, 1935; Thompson and Zuk 1982; Goldstein 1988), or the generational cycle (e.g. Neumann 1990; Tylecote 1990; Devezas and Corredine 2001; Papenhausen 2008). Analyses in the Marxian tradition emphasize the rate of profit as the main source of long waves (e.g. Mandel 1980; Wallerstein 1984a) or the ‘social structure of accumulation’ (Gordon et al. 1983), the regulation school refers to the ‘regime of accumulation’ (Boyer 1988).

The emergence and diffusion of new technologies and complementary institutional change that shape socio-economic development is at the core of research on long waves in the tradition of Schumpeter. His work was harshly criticized by Kuznets (1940) for its meagre empirical foundation and for conceptual weaknesses, and the debate about long wave models and the
role of innovation in it regained momentum only in the 1970s and early 1980s (e.g. Mensch 1975; Kleinkecht 1981; Freeman et al. 1982; van Duijn 1983) when most economies entered a downswing phase of a Kondratieff wave. Rosenberg and Frischtak (1983, 1984) formulated four interrelated conceptual requirements (causality, timing, economy-wide repercussions, and recurrence) for technological change to generate long cycles of approximately fifty years length that are still important criteria for validating theories of technology-driven long waves.

The first requirement (‘causality’) states that a ‘precise knowledge of what are the necessary and sufficient changes in the environment which . . . can bring out a bandwagon-like diffusion of some number of basic innovations’ (Rosenberg and Frischtak 1984: 276) is required. By implication, Kondratieff’s idea that the long wave mechanism is the driver of innovation does not meet this requirement. Schumpeter, however, has already developed the major theoretical elements, and many Neo-Schumpeterian analysts (e.g. van Duijn 1983; Freeman and Louçã 2001; Perez 2002) provide detailed explanations for why innovation is the core variable that brings about economic change as a driver of the long wave via investment decisions of innovative entrepreneurs.

The second requirement (‘timing’) calls for an explanation for why technological innovation leads to long periods of economic expansion followed by similarly long periods of stagnation spanning two to three decades, each. The diffusion of new technologies depends on the actual and expected trajectory of their performance and cost reduction potential. Timing within this process is complex as gestation periods may be long, new technology may lead to improvements in the old technology, new technologies may depend upon the availability of complementary inputs or supporting infrastructures, and lock-in effects can render further improvements within the existing technological framework more promising than the search for new technologies (Rosenberg and Frischtak 1983: 147ff). While radical inventions are randomly distributed over time, major innovations could cluster because in good (macro-) economic conditions exploiting existing technologies is profitable and therefore firms will abstain from radical innovations. Only when profit rates fall (because of an exhaustion of the potential of existing technologies) is there no alternative to innovation (Mensch 1975, 1979). But during the downswing of the long wave implementing radical innovations seems particularly risky, and therefore firms could prefer cost saving process innovations that are less of a radical than of an incremental nature (Clark et al. 1981). Perez (2002) argues that a clustering of innovations takes place in the downswing of a long wave because of the interplay between financial markets and the diffusion of a ‘technological revolution’ consisting of a bundle of interrelated new technologies that give way to a new ‘techno-economic paradigm’. Patent activity increases during upswings and decreases during downswings as the vast majority of patents are granted for incremental innovations that tend to become more important during upswings (Korotayev et al. 2011). Methodological problems complicate the empirical research on clustering of innovations (Kleinknecht et al. 2002) because there is no objective way of identifying the proper timing of innovations (e.g. its first appearance need not have a major impact) and their impact on the intensity of innovation activity (Silverberg 2003).

The third requirement (‘repercussions’) is that the impact of innovations or clusters of innovations must be strong enough to cause a sizeable macroeconomic impact (Rosenberg and Frischtak 1983, 1984). Such an impact can result from investment expenditures (buildings, machinery, equipment and raw materials), a second wave of innovations focusing on process innovations, and from new inputs that open the possibility for bringing new products to the market. Leading sectors trigger the upswing of a long wave because their key technologies have a huge economic potential and decrease the cost of production (Perez 2002). Within an economic mainstream context (and without explicit reference to the long wave debate) the concept of
general purpose technologies (Bresnahan and Trajtenberg 1995; Helpman 1998) also emphasizes the property of universal use of such technologies and their overall impact on the economy.

The fourth requirement (‘recurrence’) is to explain mechanisms that are endogenous to the economic process and that make the waves repeat themselves. As recurrence must be more than a theoretical possibility or the result of historical accidents explanations of the availability of inventions at the proper time and of the forces causing the lower and upper turning points of the long wave are required (Rosenberg and Frischtak 1983, 1984). Perez (2002) demonstrates that a long wave theory with endogenous innovation can explain innovation clustering and the recurrent nature of long waves as a result of the interplay between financial capital and production capital in a slowly changing socio-institutional framework. Technology and innovation policies of governments, systematic research and development effort of firms, and the use of ICT as a powerful means of information processing and as a tool of innovation have accelerated the development and dissemination of new technologies. Whether long waves will actually tend to become shorter depends on the characteristics and perceived risks of the new technologies, and on the scope and willingness of society to adapt to technology-driven change.

The requirements formulated by Rosenberg and Frischtak are rather stringent for explaining such a complex phenomenon that is characterized by multi-causality, autonomous political and social influences, and numerous feedback effects (Freeman 1996). Two more conceptual questions were raised later (Goldstein 1988; Mandel 1992; de Groot 2006): Is there an influence of wars and international relations on long waves, and are they internationally synchronized? Both questions are disputed and need further research: while some authors argue – last but not least for reasons of statistical treatment – to leave wars out from long wave analysis (van Duijn 1983), others include wars because structural changes in economic history could not be explained in ignorance of the concrete historic ruptures (Freeman and Louçã 2001). Interestingly, in a spectral analysis long waves are found both in the original time series that include the war periods and in time series using interpolated values for the war periods (Korotayev and Tsirel 2010).

Finally, Kondratieff (1935) claims that long waves occur almost simultaneously worldwide, while Hirooka (2003) considers long waves as a technology leadership phenomenon with the possibility for lagging countries to catch up, and Goldstein (1988) holds that synchronization occurs among countries of similar stage of development. While global ‘Islands of Innovation’ remain stable over a period of at least thirty years (Hilpert 2003), innovation- and imitation-based catching up is possible as the recent economic performance of some (mostly Asian) nations has shown. ICT have accelerated the international dissemination of knowledge and have facilitated joint research and innovation effort across countries in the current long wave (e.g. through international cooperation networks, co-publication, co-patenting) that allows for a more synchronized innovation activity across nations and for catching-up processes.

The dynamics and phases of technology-driven long waves

A theory of technology-driven long waves that apparently meets the Rosenberg-Frischtak criteria developed by Perez (2002, 2010) has its focus on the transformative power of technological revolutions on the economy and on the entire structure of society. This explains ‘why economists have such a difficult time proving or disproving the existence of long waves, although historical memory and the people of each period clearly distinguish the “good times” from the “bad times”’ (Perez 2004: 218). Therefore the notion ‘long wave’, which is more suggestive of cyclical fluctuations around a growth path (Escudier 1990), is replaced by ‘long surge of development’ (Perez 2002).
The dynamics of a long surge starts with a set of interrelated radical breakthroughs (a ‘technological revolution’) that are strongly interconnected and that have the capacity to profoundly transform the rest of the economy by establishing a new ‘techno-economic paradigm’. This is a best practice model for the most effective use of the new technologies within and beyond the new industries, which breaks the existing organizational habits in technology, the economy, management and social institutions (Perez 1983, 2002). When markets get increasingly saturated and the potential for improvements within this paradigm get exhausted, the speed of change and diffusion slows down and profitability of investment within the techno-economic paradigm decreases. Consequently, both real-economy entrepreneurs and financial investors start searching for opportunities outside the prevailing paradigm, thereby giving way to a new techno-economic paradigm.

The diffusion of a technological paradigm (see Figure 3.1)\(^3\) starts with the first appearance of a new technology (a ‘big bang’ like Intel’s first microprocessor in 1971) that is characterized by rapidly falling relative cost, almost unlimited availability over long periods,\(^4\) and a strong potential for use or incorporation in products and processes all over the economy. After having started from a small industrial base, in the frenzy period the wealth creating potential of the new paradigm and the exhaustion of the still prevailing old paradigm become apparent. Entrepreneurs try to find out the most profitable business opportunities created by the new technology; deregulation of the economy and financial innovations – both typically occurring in the frenzy periods – support this process. While science-based innovation supported by government policies has triggered development in the early phases of the current development surge, technology-based innovation has become more important later as new technologies have been increasingly applied in traditional products and industries.

Examples of innovative firms that have successfully adapted to the new technologies cause profit expectations and demand for similar investment opportunities to rise. Stock markets are booming in the frenzy period, even people with modest salaries turn into ‘hopeful “investors”’ (Perez 2002: 3), until ‘irrational exuberance’ (former chairman of the Federal Reserve Board, Alan Greenspan) and wild financial speculation come to an end. The build-up of a speculative bubble (and its burst) is endogenous to long surges of development: It is driven by opportunity pull caused by technological innovation such as the dot-com bubble and subsequent NASDAQ collapse in 2001 or by easy liquidity push caused by financial innovation such as the financial bubble emerging due to lack of financial market regulation which burst in 2008 (Perez 2009). Both bubbles at the beginning of the twenty-first century are related to the unfolding of the techno-economic paradigm, both types of bubbles can occur either simultaneously or sequentially, and are followed by a recession or even depression.

At the ‘turning point’ of the development surge the mismatch between the new paradigm and the still prevalent old paradigm gets most apparent. Because change in technology is discontinuous and fast but change in the socio-institutional framework is slow and lagging behind technological change, various types of mismatch between these systems arise (Tylecote 1994): microeconomic (firm organization does not suit to the paradigm), macroeconomic (macro-economic factors prevent demand to grow sufficiently), and socio-political mismatch (socio-political tensions arise from the diffusion of the new paradigm), each type having a national and an international dimension. The existing regulatory and institutional framework restrains the exploitation of the new paradigm’s full economic potential, and the build-up of a financial bubble is the expression of an increasingly dysfunctional relationship between production capital and financial capital. Possible social benefits from the implementation of the new paradigm notwithstanding, many individuals and groups have strong vested interests in the old paradigm and will be reluctant to change. The transition from the prevailing old paradigm to the new
paradigm is a time of social conflict as the structural changes coming along with the change of paradigms do not only produce winners but also losers.

In the deployment period large parts of the population have access to the new infrastructure, have the appropriate physical equipment, and accept new technologies as the advantages of the new economic paradigm have become apparent. While during the frenzy period financial capital had been geared towards short-term gains from financial speculation, the deployment of the new paradigm would need now a more stable financial system, which is to be achieved by more rigorous government control (Kregel 2009: 203). Investors could turn now from the financial economy to the real economy thus rendering possible a ‘golden age’ of the diffusion of a techno-economic paradigm like mass production did during the post-World War II boom. Whether such a golden age will eventually be reached depends on establishing a socio-institutional framework that is conducive to the exploitation of the benefits of the already established techno-economic paradigm. In particular, a new balance between individual and social interests has to be found. Ultimately, every paradigm will reach the stage when its potential to further increase wealth and productivity is exhausted in the maturity period. Modernization and restructuring return to the political agenda as the prevailing paradigm becomes less attractive for parts of the population while others still benefit from it; political and ideological confrontation is likely to arise. Real-economy entrepreneurs and financial investors will start searching for opportunities outside the prevailing paradigm, thereby giving way to the next technological revolution and to the upcoming of the next techno-economic paradigm.

**Policy-related aspects of technology-driven long wave theories**

**Policy can have an impact on long-term socio-economic development**

As theories of long waves or long surges of economic development stipulate the recurrence of economic phenomena the question arises whether these theories would be sufficiently
non-deterministic in order to allow for a potential impact of economic policy on the course of economic development. Kondratieff (1926, 1935) already emphasized that the repetition of certain processes is not subject to the same degree of determinism as, for example, in astronomy. Based on an analysis of the changing uses and meanings of the concept of long waves in the economy over time, across cultural and language borders, and across disciplines Escudier (1990) suggested that long waves be considered transformations rather than repetitions of previous stages, and thus the concept is distinctly non-deterministic. Therefore the dimension of time in the analysis of socio-economic development cannot be captured by a time index given to variables but time is historical time and thus an important dimension of analysis by itself. Technology-driven long waves evoke social processes that can decelerate or accelerate the diffusion of a techno-economic paradigm in historic time. Long wave theories that stipulate the recurrence of economic phenomena have a heuristic value through providing a structure with which regularity can be assessed and uniqueness of historical development can be fully valued (Perez 2002: 161).

With respect to economic policy relevance the long wave literature is divided into ‘two camps’ (Dator 1999: 369): one camp seeks ‘to find in the long waves the forces which will finally bring down capitalism and usher socialism’, although apparently without success so far. The other camp searches for ‘a set of economic measures . . . that will either speed up the recovery or allow given states to emerge [from the downswing of the Kondratieff wave] in a good relative position’ (Wallerstein 1984b: 579). This paper is clearly sympathizing with the latter camp as it holds that the descending phase of the long wave (in Kondratieff-Schumpeter-type theories) or a golden age of deployment of a new techno-economic-paradigm (in Perez’ theory) do not occur automatically but the diffusion of a paradigm, the related benefits, and the distribution of these benefits across social groups are influenced by policies. In Figure 3.1 the space between the two upward sloping curves in the deployment period schematically symbolizes the possible implications of two institutional designs on the diffusion of the new techno-economic paradigm and the related benefits to be drawn from it. While it is likely that the policy impact is not sufficient to cause a downswing or upswing when considered alone (Tylecote 1990), the arrows in the diagram symbolically mark the potential impact of policies on establishing a set of institutions in the turning point phase that accommodate either better or worse to the paradigm.

Having entered the decade after a ‘turning point’

There is no full agreement among long-wave researchers about the phase in which the economies of (at least) the developed nations currently are. On the one hand the financial crisis and global recession could constitute a deflationary depression like the crash of 1929, which would be typical for the ending of a Kondratieff wave (Gore 2010: 722ff). On the other hand the decade 2011–2020 could be ‘probably one of worldwide economic expansion corresponding to the second half of the expansion phase of the fifth Kondratieff wave’ (Devezas 2010: 739). Based on a long wave approach, Synnott (2012) finds that long-term real interest rates in the United States will remain low for an extended period which would be a good basis for investment and growth as in previous long waves. The fifth Kondratieff wave having emerged, ‘the information and communications sector will replace energy, transport and material as the central sector in the economy’ (Göransson and Söderberg 2005: 210). Thus it seems likely that the developed nations have entered the deployment period of the ICT-based techno-economic paradigm (Perez 2009; Reati and Toporowski 2009) after the ‘double bubbles’ of 2001 and 2008 which have marked the ‘turning point’ of the paradigm.
Different modes of regulation over a long wave’s lifetime

In the installation period individual interests govern the mode of regulation and pro-business governments tend to dominate politics (Perez 2002). Deregulation or – in the case of newly emerging technologies – non-regulation is considered conducive to innovation and economic growth because the incentives to experiment with new technologies and to innovate would be strengthened if successful entrepreneurs are rewarded with extremely fast growth of their business and huge profits.

In the synergy phase a re-coupling of the real economy and the financial economy requires:

- the elimination of the excessive financial layering through a financial collapse, and
- increased regulation of the financial system through more rigorous government control in a way that does not prevent the full deployment of the new technology led by production capital reaping the full economic and social potential of the now prevailing paradigm.

(Kregel 2009: 203)

‘Concerted open market operations to regulate liquidity in the financial markets . . . would eliminate the excess liquidity in the markets that are the origin of financial speculations and bubbles’ (Reati and Toporowski 2009: 186).

Inequality and income policy changes over the long wave’s lifetime

The frenzy period is not only the high time of individualism but also one of creating enormous individual wealth that is characterized by ‘a huge process of income redistribution in favour of those directly or indirectly involved in the casino, which funds the massive process of creative destruction in the economy’ (Perez 2002: 116). In this period the process of income concentration is fostered by unemployment and stagnating or even decreasing income in those industries and jobs that do not benefit from the roll-out of the new techno-economic paradigm. Historical analysis (Berry et al. 1995) suggests a parallel movement of technology-driven long waves and long political swings: four long surges in inequality in the history of the United States occurred in the aftermath of major stagflation crises, and each surge was followed by an ‘egalitarian backlash in which a political agenda dominated by technological innovation, efficiency and growth was replaced by one concerned with social innovation, equality and redistribution’ (Berry et al. 1995: abstract).

Periods of increased inequality occur in the early stages of the development of a new techno-economic paradigm (the installation period) and are followed by periods of less inequality when paradigms mature (the deployment period). This does not necessarily mean that new technologies and innovation require social inequality to emerge or widen, but in a market-dominated environment that was typical for the installation period of the ICT-based techno-economic paradigm values such as solidarity are not ‘fashionable’ in such times. Therefore it is difficult to get topics that are in a social-democratic tradition (such as reducing inequality or redistributing income) onto the political agenda.

The deployment period might see a tendency to reverse income concentration because the increased inequality constrains the purchasing power of significant parts of the population and the state which, in turn, constrains the demand for goods and services related to the new techno-economic paradigm. As consumers forego potential benefits and firms forego profit opportunities ‘the case for a Keynesian policy of demand’ (Reati and Toporowski 2009: 164ff) is suggested.
for the turning point period. In order to prevent countries falling into deflationary recessions ‘the IMF and the World Bank should be brought closer to the original Keynesian ideal’ (Freeman 2011: 23), and in order to reduce inequality social policies should get priority and taxation should return to the principle of redistribution (Freeman 2011: 23f). It is important to recognize that the argument for policies that reduce inequality and foster demand at the beginning of the deployment period does not resort to social policy considerations but can be based on purely economic grounds.

The new socio-institutional framework can either establish ‘institutions for increasing social cohesiveness, improving income distribution and general wellbeing or it can try to reinstate the “selfish prosperity” of the frenzy period, though more closely connected with real production and finding some means to expand demand’ (Perez 2002: 53). Currently it seems doubtful whether political decisions have been adequate to provide a better fit between the techno-economic system and the socio-institutional framework to warrant another ‘golden age’ of economic development (e.g. Castellacci 2006; Tylecote and Ramirez 2008; Perez 2009; Reati and Toporowski 2009; Gore 2010; Freeman 2011).

An active role for technology policy

Theories of technology driven long waves suggest an active role of government in supporting technological development. In the installation period the risk that a nation misses out on taking up the technological developments that are the key elements of a new paradigm should be reduced. Such a policy requires a long time horizon and could include supporting major infrastructure investments in the new technology even if profitability is not yet warranted, and creating a research and policy climate that tolerates mistakes, particularly in basic research, and building competences in the public sector to enable government to implement technology policies appropriately (Drechsler et al. 2009). Both in the installation and in the deployment period the design of sectorial, national and regional systems of innovation is important for a country’s adaptability to the requirements of the new techno-economic paradigm and its capability to benefit from it.

The process of adjusting to a new techno-economic paradigm in general and to successfully approach the emerging key technologies in particular is critical for a nation’s ability to keep its relative position of economic welfare or even to start a catch-up process. While changes in the techno-economic paradigm create new opportunities particularly for newly industrializing countries and increase the potential for national public policies to support catching-up processes, institutional change at the international level seems to reduce the scope for state intervention (Castellacchi 2005: 32f). This paradox suggests a mismatch between the techno-economic and the socio-institutional system that makes catching up difficult. The situation is complicated further because institutions that work in one social-political-economic context cannot necessarily be transferred and adapted to the conditions of another (Nelson 2009: 283). While this clearly indicates that there is no ‘one best way’ of policy it also highlights the importance of policies and understanding policy environments for a society to benefit from the dissemination of a new techno-economic paradigm.

Notes

1 Neither Kondratieff nor Schumpeter knew about van Gelderen’s work which was published in Dutch; it was translated to English only in 1996. Kondratieff’s work had been translated from Russian to German in 1926 and to English in 1935.
See Table 3.1. The dating of the first two and a half waves is equal to Kondratieff (1926, 1935), the dating of the latter waves are influenced by Goldstein (1988), Freeman and Perez (1988), and Perez (2009). Waves are named according to Freeman and Perez (1988). Leading countries are mostly taken from Freeman and Perez (1988), leading branches of the economy, transport and communication infrastructure, and managerial and organisational characteristics are based on Freeman and Perez (1988) and Reati and Toporovski (2009).

The dating of Perez’ surges of development differs from the dating of traditional long waves.

In the case of the ICT surge this is best reflected in the steady and long-term decrease of computing power cost which is described by Moore’s law.

Bibliography


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