Why the great surges of developments are different: a coupling analysis of the socio-political paradigm and the techno-economic paradigm

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Abstract

Purpose – The "problem-ridden present" is indubitably related to the prevalence of neoliberalism, but it is also when the fifth technological revolution took place. In this special time, what should be done to achieve the coupling of Socio-political Paradigmand Technoeconomic Paradigm through the adaptive transformation of socio-political paradigm to avoid the resurfacing of the "problem-ridden present"?

Design/methodology/approach – The obvious difference between the efficacy of the fifth technological revolution and the previous four indicates that the Techno-economic Paradigm of Neo-Schumpeterian school is not sufficient enough to explain the institutional obstacles. No matter institutional or technological, any single perspective would not be adequate to explain the fundamental cause of the "problem-ridden present".

Findings – From a historical materialism standpoint, the structure and progress of the techno-economic paradigm are inevitably influenced by the socio-political paradigm, and only when the techno-economic paradigm and the socio-political paradigm are coupled, the potential of the wave of technological revolution can be "shared release."

Originality/value – The coupling analysis of the Socio-political Paradigm and the Technoeconomic Paradigm is of great enlightening value to the understanding of the economic development in the Digital Economy era.

Keywords Neo-Schumpeterian theory, Kondratieff's long waves theory, Technoeconomic Paradigm, Social-political Paradigm

Paper type Translated paper

In regards to the long-term analysis of the technological revolution fluctuations, Carlota Perez believes that the analysis of historical progress should be free of the traditional view that the cycle is only a rise and a decline in GDP. Therefore, Kondratieff's long-wave theory should be replaced by the great surges of development. The structure of each technological revolution is what the analysis should focus upon, particularly the studies of its pattern in diffusion and assimilation throughout the economy and society. The great surges of

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development are a process of technological revolution and its paradigm spreading in the whole economy, and it leads to not only structural changes in production, distribution, exchange and consumption but also profound qualitative changes in the society.

Although each surge is roughly the same length in time, not all waves have the same socio-economic efficacy. On October 18, 2017, Nature published the work by the economic historian, Robert C. Ellen, *Lessons from History for the Future of Work*. In this article, Ellen points to the fact that compared with Engel's Pause in Britain during the first industrial revolution, the situation in the United States of America has been much worse since the 1970s. Britain experienced a 60-year hiatus in wages despite the labor productivity growth since 1770, while the United States of America experienced a much larger divergence between wage growth and labor productivity growth. This has also been accompanied by a much higher degree of inequality in income distribution. This implies that the Americans have not enjoyed the benefits of economic growth for nearly half a century since the 1970s, and thus, Ellen refers to the 1970s as the "problem-ridden present" and the period between 1830 and the 1970s as the "Western ascent to affluence" (Allen, 2017).

In contrast to the three decades of post-war coordinated growth in profits (accumulation), real wages (consumption) and labor productivity (technological progress), Ellen only points to the gap between real wages and labor productivity. In fact, whether we look at the rate of profit, the rate of investment, the rate of employment or the growth of real wages, since the mid to late 1970s, the Western developed countries, represented by the United States of America, are increasingly showing signs of increasing financialization, sluggish economic growth, low investment and social inequality. The terms Great Stagnation, Great Moderation, Great Failure, Great Depression and Decoupling are widely used to describe the post-golden age of Western economies. The rise of neo-liberalism since the late 1970s and early 1980s and the ensuing policies of financialization, liberalization and privatization are widely believed to be the root cause of the "problem-ridden present." Why did the economies of the developed world, represented by the United States of America, grow so rapidly in the middle of the 20th century? Why did growth slow from the 1960s to the early 1970s? These are the most fundamental questions in modern economic history according to Robert J. Gordon. In Gordon's view, economic growth is not as relentless as Solow envisioned but is likely to be a one-off event in human economic history. The question since the end of the post-war golden 30 years is not how long growth will last, but how far it will decline. Gordon predicted that the USA economy faces six long-term headwinds: demography, education, inequality, globalization, energy and environmental issues and excess consumer and government debt. These will push the long-term growth rate of the economy to half or less compared to the 1.9% annual growth rate from 1860 to 2007, while per capita consumption growth in the bottom 99% of the income distribution is likely to be below 0.5%. Mullen argues that since the 1970s, the West has been in a "long depression" similar to the Great Depression of the 1920 and 1930s and that many of the problems have been caused by what Mullen calls a "depression depression," in which governments have been trying to contain and alleviate the depression with short-term policies rather than focusing on long-term economic growth, and therefore suppressed the creative destruction effects. In addition, Hal Brenner described the period as a long slump, and Cohen described it as a great stagnation (Tyler Cowen, 2011) and a great failure.

The rise of neo-liberalism paralleled with the "problem-ridden present," but it cannot be ignored that the "problem-ridden present" also correlated with the fifth technological revolution, where the information and communications technology (ICT) revolution played a major role. Why is it that the first four technological revolutions corresponded to the "age of prosperity," while the fifth wave of technological revolution was related to "problem-ridden?" What caused the difference between these periods of advancements? This certainly presents some challenges for neo-Schumpeterian economics, as it stands by the principle that

innovation is the driving force of economic growth. If following the stages of the technological revolution of neo-Schumpeterians, the introduction period of the technological revolution will inevitably encounter a financial crisis, which will be followed by the "turning point" period of institutional restructuring and then lead to an expansion period. However, the two successive great financial crises since the 21st century, the Nasdaq storm at the beginning of the 20th century and the great crisis during 2008, did not establish a turning point. Although to a certain extent, the traditional theory of the techno-economic paradigm swayed away from the technological determinism tendency and achieved institutional analysis, it still fails to explain the structural influence and the formation of institutional obstacles during the different waves of technological revolution.

Considering the materialistic conception of history, the release of the economic potential of any technological revolution could not be directly measured by the technological advancement itself: it is closely related to the society's political environment, principles and policies. As the process of any technological revolution is a continuous and progressive process, its economic value is not natural release, but it's rather restricted by the socio-political paradigm. It is generally agreed that the world economy is now in a period of overlap between the end of the fifth and early stages of the sixth technological revolution. The digital economy (hereinafter referred to as digital economy 1.0) based on the Internet, computers and other ICTs is growing toward a new generation of digital economy (hereinafter referred to as digital economy 2.0) represented by artificial intelligence (hereinafter referred to as AI). In this special time, what should be done to achieve the coupling of socio-political paradigm and techno-economic paradigm through the adaptive transformation of socio-political paradigm to avoid the resurfacing of the "problem-ridden present"?

1. From the technological paradigm to the technological economic paradigm: the institutional analysis approach of neo-Schumpeterian economics

For the neo-Schumpeterians, Joseph Schumpeter's theory is more enlightening than explanatory in terms of studying the underlying mechanics of the long wave or the "great surge." Although Joseph Schumpeter is recognized as the originator of the innovation theory, his contribution is simply to point out innovative technologies as the main force driving economic growth. His work didn't provide any satisfactory explanations in regards to how this force is acquired, how it occurs and how it affects long-term economic fluctuations. Freeman points out that Joseph Schumpeter's *Business Cycles: A Theoretical, Historical, And Statistical Analysis of the Capitalist Process* was considered a major theoretical contribution at the time; half a century later, it cannot be said that Business Cycles occupies a place in the history of economic thought comparable to the major works of Marx, Keynes or Ricardo, or even other works of Schumpeter himself: "Schumpeter remains the rogue elephant amongst 20th-century economists, and although he has commanded the respect of the profession, he certainly has not won their allegiance" (Freeman, 1990).

There are mainly two facets of the criticism in regards to Joseph Schumpeter's business cycle theory. The first is how to explain the scale and duration of innovation. Simon Kuznets's known review of the business cycle in the *American Economic Review* represented some of the typical questions: Which innovations were so big in their scale that they could possibly drive long cycles of the entire world economy? There are tens of thousands of inventions and innovations every year. Surely some theory of the clustering of innovations would be necessary to relate innovations to major waves of investment and long cycles of development. Also, why should a long cycle last about half a century? If it is entrepreneurial energy which drives the whole system, then Kuznets asked ironically: did the heroic entrepreneurs get tired every 50 years (Kuznets, 1940)? The second is Vernon W. Ruttan's challenge to the clusters of innovations hypothesis. "Neither in Business Cycles nor in

Schumpeter's other work is there anything that can be identified as a theory of innovation. The business cycle in Schumpeter's system is a direct consequence of the appearance of clusters of innovations. But no real explanation is provided as to why innovations appear in clusters or why the clusters possess the particular types of periodicity which Schumpeter identified [. . ..]" (Ruttan, 1961). Joseph Schumpeter was unable to answer the question of Simon Kuznets until his death. After Joseph Schumpeter, Mensch and others have tried to prove that depressions cause innovation to swarm, but they have also failed to provide a good explanation for the cyclical nature of the swarm.

After Mensch, neo-Schumpeterians have been trying to make up for the flaws in Joseph Schumpeter's theory, such as Freeman's new technology systems, Dosi's technological styles and technological paradigms proposed by Cluck and Suter. These all aimed at elucidating the mechanism of the occurrence and diffusion of technological innovation. Perez' studies systematically responded to Ruttan and Simon Kuznets's criticisms (Freeman, 1990). Based on Dosi's concept of technological paradigm, Perez came up with the concept of meta-paradigm and developed the theory of techno-economic paradigm. While based on the concept of Joseph Schumpeter's innovation as an economic driving force, Perez argues that the wave of technological revolution is not strictly an economic phenomenon but rather a transformational process of the entire socio-economic and institutional system. Therefore, in her theory of techno-economic paradigm shifts, Perez strives to get rid of the tendency of technological determinism of the early neo-Schumpeterians such as Mensch. Perez colored the long-wave theory of neo-Schumpeterian an obvious tint of institutional analysis: First, Perez introduced the concept of institutional reorganization in the periodic fluctuation of technological revolution and regarded it as a key factor in the transition from trough to peak. Second, Perez believes that the transition between financial capital and the dominance of productive capital is the only pathway from the introduction period of the technological revolution to the expansion period. When Perez suggested that the fluctuating process of the technology wave with the dominance of financial capital and industrial capital and expressed the view that the potential of the old technological economic paradigm would not be replaced before it was exhausted, she was actually aligning with Marxism. Andrew Tylecote thus described Perez's theory as "This is a most elegant synthesis of the best of the Marxist and Schumpeterian traditions" (Tylecote, 1992, p. 18).

In the theory of techno-economic paradigm, the technological revolution, techno-economic paradigm and the great surges constitute an inseparable organic whole that advances sequentially and logically. Although the technological revolution first occurred in some economic sectors, it lacks the efficacy to transform the social economy as a whole. However, it's different for the techno-economic paradigm accompanying the technological revolution, which possesses an exemplary significance for the whole society. "A techno-economic paradigm is, then, a best-practice model made up of a set of all-pervasive generic technological and organizational principles, which represent the most effective way of applying a particular technological revolution and of using it for modernizing and rejuvenating the whole of the economy. When generally adopted, these principles become the common-sense basis for organizing any activity and for structuring any institution (Perez, 2003, p. 21). Whether a potential technological revolution can become reality largely depends on the degree to which the techno-economic paradigm is generally accepted. When such a paradigm is spread out in a comprehensive manner, the "great surge of development" will take place, leading to structural changes in production, distribution, communication and consumption as well as to profound and qualitative changes in society" (Perez, 2003, p. 25).

There is an inherent consistency between Perez's technological economic paradigm and Dosi's technological paradigm. Just as there is a Thomas Kuhn Community Paradigm for Scientific Research, there is a developmental paradigm for technology, Dosi argues: "The technological paradigm can be defined as a model for the solution of selected technoeconomic

problems based on the principles of the natural sciences" (Dosi *et al.*, 1988, p. 276). Essentially, Dosi's technological paradigm is a kind of logic followed in the process or development of technological activities, but it does not imply a consistent state. This paradigm follows progressive, evolutionary and heuristic logic, and within this logical framework, the collective embodiment of technology and its products would lead to a set of particular technological trajectories.

On the surface, Dosi's technological paradigm is more about the evolution of technology solutions, so it is often regarded as a kind of technical analysis, which is obviously a misunderstanding. We can have a clearer understanding of the institutional attribute of the technological paradigm through Dosi's classification of knowledge. From Dosi's perspective, technological progress involves different types of knowledge: universal and encoded knowledge, non-public and tacit knowledge or knowledge that is protected by patents. In the process of constructing and utilizing this knowledge, the subject will be affected by the originally existing cumulative knowledge of the enterprise and therefore form a specific solution. Thus, "innovative knowledge is bound by a paradigm and appears along a particular trajectory" (Dosi *et al.*, 1988, p. 278). In this sense, innovative knowledge is specialized and sector-specific, yet knowledge is a cumulative asset at each single enterprise. An enterprise that follows the technological paradigm to solve problems would end up with resulting products and technological trajectory with a high degree of heterogeneity, and so we could observe each different enterprise with a unique innovation trajectory. This approach to understanding technology through familiarity with knowledge is also a key difference between neo-Schumpeterian economics and mainstream economics, which extrapolates technology from output to outcome, regardless of the nature of the technology. When it comes to neo-Schumpeterian economics, a technological change is based on scientific principles, directed by needs and problems and is subject to the interaction of cumulative knowledge. This is certainly different from the neoclassical economic view of technology as a widely applicable, easily reproducible and reusable concept of information.

The technological paradigm is a micro-concept that discusses what technology is and how it is constructed. The techno-economic paradigm is a macro-technological concept, which expresses the general characteristics, diffusion process and macro-expression of technology in the economic system. Nevertheless, both the technological paradigm and the technological economic paradigm have obvious institutional meanings, and they just describe the formation of "common knowledge" in institutional economics at different levels. Whether it is Dosi's emphasis on the need for technological innovation to follow specific procedures and be subject to specific constraints or Perez' statement that "each technological revolution brings with it, not only a full revamping of the productive structure but eventually also a transformation of the institutions of governance, of society and even of ideologies and culture" (Perez, 2003, p. 30), the key is to emphasize the blending and configuration of "common knowledge" at different levels. From the form of production organization to the mode of circulation and consumption, as well as the form of organization and the structure of system, the techno-economic paradigm embodies the universality of economic activities as a result of technological revolutions. In a sense, it is an equivalent set of analytical concepts with another important concept of neo-Schumpeterian economics, general purpose technology; the latter refers to widely used technical arrangements, while the former implies a widely accepted institutional structure.

The formation of the techno-economic paradigm indicates that the neo-Schumpeterians, such as Freeman, Luzan, Taylor Cote and Perez, have shifted their focus from technology-driven economic growth to areas such as the interrelationship of different technologies, their diffusion patterns and their impact on innovative directions. Exemplary topics include: how does technology lead to changes in corporate and institutional organizations? How would

technology affect employment, lifestyle and market structure? The concept of "great surge of development" not only removed the limitations of traditional long cycle analysis but also represented neo-Schumpeterians' efforts to better modify Joseph Schumpeter's legacy through rational historical analysis. This modification from technological paradigm to techno-economic paradigm is relatively successful. Dosi's technological paradigm theory, as a knowledge generation theory, is widely used in innovation economics and can provide theoretical basis for business heterogeneity theory and dynamic capability theory. Perez' theory of techno-economic paradigm can not only include the process of technological change but also the elements of institutional competition and institutional inertia, so it is possible to become a more macro-historical pattern of the stage of capitalist development theory. As a type of long-term historical institutional analysis, the techno-economic paradigm is not only a breakthrough of the early technological determinism but also an upgraded extension of the technological paradigm. Unfortunately, techno-economic paradigm still underestimates the importance of ideas, interest groups, social policies and so on, and this greatly weakened the scope of application and interpretation of this theory – it judges a turning point period too quick and marks a system reorganization too easily.

2. Brief turning point and easy institutional reorganization: the inherent deficiency of the theory of technological economy paradigm

After Mensch, neo-Schumpeterians such as Freeman, Louca and Perez have been trying to avoid technological determinism and move as far as possible towards a co-evolutionary theory. The techno-economic paradigm is the exact embodiment of this endeavor. However, this paradigm is still regarded as technology determinism to some critics. Gutiérrez-Barbarrusa argues that while both the Neo-Schumpeterian School and the Social Accumulation Structure School (SSA) view profit margin as a central determinant of the accumulation process, there are still fundamental differences on the relationship between the two. The social accumulation structure school argues that the effects of technological change are largely mediated by the institution, but for neo-Schumpeterians, the institutional environment is created by the long wave, and it's the result of social and economic transformations unleashed by technological progress. The reason for this difference lies in the fact that the neo-Schumpeterian mainly focuses on micro-level analysis, while the SSA focuses on macro-economic analysis, which results in "reversal of causalities between the two theories" (Gutiérrez-Barbarrusa, 2019).

Tomás Gutiérrez-Barbarrusa's assessment applies only to the early Schumpeterians, such as Mensch, but to the neo-Schumpeterians after the 1980s, such as Perez, Freeman and Dosi, it may not be entirely appropriate to consider its theoretical view as "the institutional environment is still created by the long wave." The neo-Schumpeterian techno-economic paradigm is not a kind of technological determinism. It is worth discussing whether the theory of the techno-economic paradigm leaves enough theoretical space for institutional transformation analysis. In fact, Freeman and Loucã conclude that the appropriate method is " . . . reasoned history: for 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" (Freeman and Loucã, 2001, p. 123). Thus, the main ontology is that of co-evolution. Five subsystems in society are identified: science, technology, economy, politics and culture. Subsystem cycles, lags and feedbacks " . . . are combined in some bands of fluctuation by specific coordination processes emerging after structural crises. These coordination processes are therefore the crucial causal determination for the business cycles and the long-wave movements in real historical development . . ." (Freeman and Loucã, 2001, p. 121) [1]. This clearly shows that the neo-Schumpeterian view of the long wave is the result of the co-evolution of three subsystems:

technology, economy and society, with the peak being their best coupling period and the trough being the worst. Although Freeman and Perez did express that institutions transform along with the technological progress, "a particular type of technological progress, defined as a 'technological economic model', has such a broad impact on all sectors of the economy that their diffusion is accompanied by a structural crisis of adjustment, in which case the transformation of the social and institutional system necessarily leads to a better match between the new technology and the system of socio-economic management or the system of rules" (Dosi *et al.*, 1988, p. 49), it does not mean that they put technological innovation in a decisive position. In her analysis of the alternation between the new and the old techno-economic paradigm, Perez emphasized that "the surges refer to the emergence and process of diffusion and socio-economic assimilation of successive (and overlapping) technological revolutions" (Perez, 2013). Nelson also points out that Christopher Freeman and Carlotta Perez have proposed that the key technologies and industries of different eras generally require different sets of supporting institutions. Their argument is that the nations that tend to be leaders in the different eras are those that had, or managed to build, the appropriate set of institutions (Nelson, 2011).

The real deficiency of the techno-economic paradigm lies in the difficulty of adjusting the system, and the critics took this chance. For a theory of long-term fluctuations in capitalist development, the core issue is not how to explain the occurrence of peak and trough but how to resolve the structural crisis and push the economy from trough to peak. Perez realized the importance of troughs getting the needed upward momentum, and so in the transition period between the introduction and expansion, there must be a period of adjustment, i.e. the turning point, where the reorganization of the system can be accomplished. However, Perez is overly simplistic and optimistic. In her opinion, the turning point represents a fundamental shift from a mad model based on financial standards to a coordinated model based on the production logic, with productive capital seizing power from financial capital. This is a process deemed relatively easy by Perez: "it is a process of contextual change. It can take any amount of time, from a few months to several years" (Perez, 2003, p. 52). In her depiction of the five technological revolutions, the turning point of the first technological revolution lasted only four years (1793–1797), the second lasted five years (1848–1850) and the third lasted only two years (1893–1895). Due to warfare at the time, the turning point of the fourth technological revolution lasted four years in Europe (1929–1933) but 14 years in the United States of America (1929–1943). In her book published in 2002, Perez identified the turning point of the fifth technological revolution as the beginning of 2001 (Perez, 2003, p. 52), and this prediction clearly does not correspond to the later economic development since 1995–2004 was the golden decade of the ICT revolution (Gordon, 2018). This means that the 2001 Nasdaq crisis did not have the destructive repair function of the financial crisis described in the techno-economic paradigm, and 2001 was not the beginning of the turning point. After the onset of the financial crisis in 2008, Perez had to revise her earlier view that 2007–2008 marked the end of the phase of ascent or consolidation and that we were once again at a turning point (Gutiérrez-Barbarrusa, 2019).

The turning point was short-lived to a large extent because Perez attributed the institutional reorganization of this period to the tug-of-war between the new and old techno-economic paradigms as well as the alternation of productive capital and financial capital. In regards to the alternating dominance of financial capital and productive capital, Perez only emphasizes the flexibility of financial capital and the resulting positive impact on the diffusion of innovation, arguing that once profit expectations are not met, financial capital would surrender dominance to productive capital, which clearly understates the complexity of the modern capital system. It is true that financial capital provides the necessary financing mechanisms for the development of new technologies and plays a fundamental role in achieving long-term economic expansion, but when new technologies do not provide the

profit prospects that financial capital expects, the bursting of the financial bubble does not automatically put financial capital into hibernation. The process of financialization is not limited to the financial industry itself but permeates the real economy and the daily life of each individual. In the general financial system of economic life, the speculative profits of financial activities always constitute a diversion and restraint to the productive investment of enterprises. On the one hand, corporates can make money by taking equity stakes in financial institutions, mergers and acquisitions or management buyouts. On the other hand, financialized non-financial corporates must also invest a sizeable speculative portion in the financial markets to maintain the necessary liquidity for risks and uncertainties. This required liquidity objectively reduces the amount of capital that firms can invest in new technologies, equipment and research and development. In fact, widespread and pervasive financialization has blurred the boundaries between the productive capital and her financial capital, which makes Perez's conception of the power dynamics between the productive capital and the financial capital seem too idealistic.

Despite an effort to emphasize the co-evolution of technology, economics and institutions, as the critics point out, "A weakness of the neo-Schumpeterian theory is a lack of theory of agency, which limits its ability to provide explanations of the mechanisms of growth processes (Köhler, 2012)." Geels and Schot (2010) argue that it is too " . . . focused on the macro-environment of socio-technical systems . . . and does not provide many insights into how these transitions happen" Geels and Schot (2010, p. 17) [2]. Due to such disadvantages of non-action subject and focusing too much on macro-environment analysis of technological systems, the techno-economic paradigm of the neo-Schumpeterian has only won the system magnificence in institutional analysis but lost the structural details. The form of production organization and the change of dominant paradigm is more like a brief institutional cost-benefit analysis than an institutional evolution analysis. In the theory of the techno-economic paradigm, the paradigm accompanying with technological revolution has been of universal exemplary significance since its inception. In fact, there cannot be a clear and defensible institutional paradigm until the potential of a technological revolution has been fully realized.

As a result of the co-evolution of technology, economy and institution, it is impossible for this paradigm to have an ideal and balanced pattern – it can only be a combination of institutions with historical specificity. It is the continuous interaction and co-evolution that formed a kind of "universal" economic form. This co-evolution process also witnessed conflicts and compromises among different classes and social forces, until finally "one political-economic program is able to defeat its rivals or an historic compromise might be reached" (McDonough, 2011, p. 1241). The transition of techno-economic paradigm is not only the power alternation of financial capital and productive capital, but it also covers many aspects such as labor-capital relations, international system, etc., and the process of the surge include the contention, confrontations and compromise of different classes or interest groups. Ignoring the complexity of institutional adjustment in the transition period makes it difficult for the techno-economic paradigm to cope with such a long "problem-ridden present" accompanying the fifth surge.

3. The dual bubbles and the institutional bias of the surge of technological revolution

The outbreak of the financial crisis in 2008 shows the defects of the techno-economic paradigm. First, according to the theory of "financial crisis in the period of introduction," the advanced economies, such as the United States of America, have already experienced the collapse and release of the Nasdaq crisis in 2001, but they experienced an even more intense financial crisis only seven years later and then entered an era of more frequent crises after

2008. This means that "there must be a financial crisis during the installation period" is questionable, while the long-wave implications of the 2001 Nasdaq crisis and the 2008 crisis also need to be reinterpreted. Second, with the fourth wave of the technological revolution – in particular, the golden 30 years of parallel growth in productivity, real wages and profit margins, compared with the fifth wave of the technological revolution – not only labor productivity, real wages and profit margins are decoupling but also financialization and inequality are on the rise (Dosi and Virgillito, 2019).

In the techno-economic paradigm, the outbreak of a financial crisis has its inevitability and rationality. Perez believes that the full unfolding of a technological economic paradigm will follow a constant order: the technological revolution will lead to the period of turbulence introduction, which will be ended by the economic bubble burst. This is followed by a period of institutional restructuring with financial regulation and thus created conditions for the expansion period. This will then lead to a period of healthy, sustained and universal growth that lasts until it reaches maturity and exhaustion. The financial capital dominance in the introduction period and the irrational investment in new technology will inevitably lead to over-investment and financial bubbles and eventually lead to another financial crisis. Although the financial crisis is highly destructive, it has established the new infrastructure necessary for the techno-economic paradigm, so the financial crisis has some certain positive impact in the initial stage of each technological surge, just like what Werner Sombart and Joseph Schumpeter call the "gales of creative destruction." Historically, the techno-economic paradigm has always been preceded by a period of financial madness and its subsequent financial collapse, such as the financial crisis caused by the railroad, the canal fever of the first industrial revolution, and the 1929 Great Crash caused by the frenzied investment in automobiles, electricity and aviation during the Second Industrial Revolution. However, the golden age of expansion will usually follow the financial crisis – as long as the productive capital dominate over the financial capital through the system reorganization adjustment period and there are appropriate policies formulated to promote healthy market operation. This period of economic expansion led by productive capital can full realize the benefits of the potential of new technologies.

However, the 2001 Nasdaq crisis did not seem to have had the effect of a "gales of creative destruction." Instead, there have been successive financial crises, such as the 2001 Nasdaq crisis and the 2008 financial crisis. This does not conform to the hypothesis of "leading-in period financial collapse" in the techno-economic paradigm. Therefore, Perez came up with the idea of "the double bubble" after the 2008 financial crisis, arguing that not all financial crises have the same nature and cause, and it's necessary to distinguish between Minsky's bubbles and those created by the way the technological revolution has spread. The former is an easy liquidity bubble (ELB), while the latter is a major technology bubble (MTB) created by the way the market economy absorbs the technological revolution. "They are the result of opportunity pull rather than of easy credit push" (Perez, 2019). Thus, the dot-com bubble of 2000 was a classic technology bubble, but the 2008 financial crisis was a liquidity bubble rather than a technology bubble.

While the double bubble may explain the different causes of the 2001 Nasdaq crisis and the 2008 crisis and gives Perez an opportunity to revise her judgment on the turning point, it does not explain the more crucial question – why did the fifth technological revolution lead to socio-economic performance so different from the fourth? Indeed, financialization was neither the underlying cause nor the sole cause of the 2008 financial crisis. "Even if finance is the single most important culprit with regard to its origin, this does not explain why the crisis has been so wide, so deep and so long" (Archibugi, 2017a, b).

The scope and areas since the ICT revolution have not achieved a greater creative effect, which is one of the primary causes of the "problem-ridden present." Research and development (R&D), technological advances and applications in the post-golden age are

more concentrated in the service sector than in the manufacturing sector (Gallouj Savona, 2009). According to Dosi, while the fifth wave of the technological revolution has also produced high-productivity sectors such as information and communications, robotics and biotechnology, their share of total demand and employment has been relatively low. The smaller size of the new economic sector and its limited application to the services sector induced the smaller job multiplier as well as the scantier productivity and wage spillover. Compared with the previous four coordinated multi-sector technological revolutions, the fifth represented by ICT has always remained in the field of information and communication and has not revolutionarily advances in other fields such as biotechnology and energy, which were carrying high expectations since the 1980s. According to the McKinsey report, the New Economy will continue to be dominated by the ICT economic paradigm until 2025, with biotechnology and new materials accounting for only 5 to 10% of the total expected contribution of new technologies. Despite significant R&D investments, biotechnology has not produced the same results as ICT, either in terms of generic technologies or applications, and the results have remained in the form of knowledge rather than products. In contrast to ICT, which continues to give birth to unicorns, most of the pioneer companies in biotechnology will be acquired by big companies as soon as they make a breakthrough. Thus, due to excessive isolation, lack of sharing and intellectual property protection, the biotech revolution has been hindered.

From this point of view, the deficiency of the neo-Schumpeterian is that it neglects the income distribution mechanism of the techno-economic paradigm and the conflicts and obstacles it causes and only focuses on the income creation mechanism of this paradigm, particularly the synergy and diffusion between different sectors. Neo-Schumpeterian believes that once the power sector producing key elements is broken through, it will naturally lead to a chain reaction between industrial sectors as well as changes in the form of production organization. The formation of industrial synergy and the spread of technology are not only an economic effect but also a social and political problem. The potential of the surge depends not only on changing broad cost-structures through technological innovation but also on overall institutional change. Before a new wave of technological revolution is launched, there is a possible set of technological gains or dividends, i.e. the economic and social impact when a wave of technological revolution is fully extended and diffused. This set of possibilities is determined by the nature of the technology itself, but the process by which the corresponding potential output becomes a real output is not determined solely by the technology, but rather by the conceptual environment in which the technology resides and by the dominant interest groups. More importantly, it is determined by the fact that the process of transforming potential outputs into actual technological outputs is not continuous and uniform but rather penetrating, gradual and unbalanced. Once the part of the actual output is realized, it will form a co-evolution process with the existing institutional structure and the behavioral subjects in the structure. This co-evolution occurs first in the areas where technology dividends are most readily available, whereby the relevant stakeholders reinforce themselves and influence the process by which potential technology outputs continue to be transformed into real outputs.

The main omission of the techno-economic paradigm is that it neglects the institutional bias of technological progress itself. A real surge of technological revolution not only involves the mechanism of creating new interests but also inevitably changes the interest distribution of different subjects. Since the formation of the techno-economic paradigm is a gradual and long process, the generation and distribution of profits are obviously biased. The departments and interest groups that received the first-hand technology profits will continue to receive such profits, and this does not necessarily lead to the unbiased "sharing" of these profits with the society. There is no techno-economic paradigm that automatically enables inclusive benefit creation and unbiased sharing. The techno-economic paradigm

emphasizes the income-creating mechanism of technological progress and does not deal with the income distribution mechanism and the conflicts and obstacles caused by it. Fundamentally speaking, the fifth technological revolution and the "problem-ridden present" did not accidentally happen at the same time. They are in fact inevitably correlated.

Financialization and the financial bubbles are directly related to the technological and product characteristics of the fifth technological revolution. These characteristics of the ICT revolution are inherently capital-biased and are more conducive to the financialization of the real economy and the flexible control of capital over labor. More importantly, once economic life becomes financialized, productive activities are suppressed and non-productive activities are enforced, which is even more detrimental to the potential productivity release and to the inclusive sharing of profits of the technological revolution. The collapse of the Nasdaq did not follow Perez's development sequence, which states that there'd be a period of adjustment and expansion after a financial collapse. In reality, a more destructive financial crisis hit seven years later. This surely is partially caused by the failed regulation after the Nasdaq crash and the flood of liquidity due to the Federal Reserve's relentless interest rate cuts after the September 11th attack, but the main reason is that the legacy of the Nasdaq crisis – from infrastructure and technology to talent – is best compounded with finance rather than the real economy.

In the 21st century, the number of initial public offerings (IPOs) in the USA ICT sector has fallen to even lower levels than in the 1980s, but IPOs in the financial sector have started to rise rapidly (Perez, 2009). Lundwall believes that the specific technical nature of ICT makes the design of financial innovation and cross-border transactions a lot easier and the whole financial transaction a lot more difficult to regulate. After the Nasdaq bubble, numerous complex financial derivative instruments were invented and thus expanded wildly. It was this kind of financial innovation based on ICT that set the stage for the financial crisis (Lundvall, 2017). Therefore, Perez's dual-crisis interpretation only highlights the differences in the nature of the two crises but does not point to the intrinsic relation between the two crises. If the Nasdaq crisis of 2001 was driven by the technology mania of ICT itself, the crisis of 2008 was driven by ICT-based financial innovation.

Unlike how productive capital regained its dominance from financial capital through institutional restructuring during the adjustment period, the real economy of the fifth technological revolution is not the traditional manufacturing but the new Internet sector. As data monopolists, the enterprises in this sector have a natural financial tendency and tend to reinforce their monopoly through financial transactions such as mergers and acquisitions to improve data utilization efficiency. In order to maximize shareholder benefits, it also needs to stabilize share prices through financial activities such as share buybacks. "This role is being increasingly played by the new giants themselves, which are now full of cash" (Perez, 2009). Numerous studies have shown that new technology companies based on data monopolies are highly financialized. Their market capitalization value does not necessarily reflect profitability and product value does not have to match its price. Companies like Amazon, Google, Apple and Facebook control more financial assets than many top investment banks. Companies are increasingly using profits to buy back shares rather than make physical and R&D investments, and the sole purpose of this is to increase shareholders' assets. The ICT revolution, characterized by technological bias in favor of financial innovation, has further intensified the process of financialization, and the financial sector has become the most heavily used area of IT products and services – there is a mutually reinforcing relationship between ICT and financialization.

The development of ICT has not only contributed to financialization but has also made it easier to achieve capital control over labor, resulting in further job polarization and income inequality. The constant development of the Internet and communication technologies has changed the demand for labor skills as well as the way in which capital employs labor. In

order to make more profits, companies tend to choose short-term employment and outsourcing. Stable labor relations are replaced by diverse capital-friendly working relationships, such as part-time, self-employment and hourly employment. This has formed the so-called Digital Taylorism, which not only heightens workers' future uncertainty but also weakens the collective negotiation power of the working class as a whole. This kind of change also disintegrates the foundation of "learning by doing" and tacit knowledge and kills the on-the-spot innovations based on skill accumulation. In the labor market, the process of production automation has been accelerated, increasing the demand for high-skilled labor while reducing the demand for low-skilled labor and eliminating a large number of traditional middle-skilled jobs. This leads to employment polarization and greater income inequality, which are among the main reasons for the apparent stagnation of wages in the "problem-ridden present."

4. The coupling of techno-economic paradigm and socio-political paradigm

Quite a few neo-Schumpeterians hope to get out of the "problem-ridden present" through the new wave of technological revolution. Perez believes that in order for this to happen, a green revolution must take place, and the environmental pressures and energy predicament will eventually lead to it (Perez, 2013). Daniele Archibugi (2017a, b), on the other hand, thinks that a new biotech revolution will be needed to reverse the current economic slowdown issue, and the aging of the population will be the catalyst of such a revolution. However, since the fifth "big wave" was accompanied by the "problem-ridden present," what reason is there to believe that the new "big wave" will inevitably resolve the "problem-ridden present"?

In Lundwall's view, the existing techno-economic paradigm cannot explain the current economic slowdown. The financial crisis of 2008 was not caused by the exhaustion of the techno-economic paradigm, and the solution is not to create a new growth sector. The main causes of the crisis and the way to solve them need to be discussed at a socio-political level but not at a techno-economic level. ICT did play a role in the rise of neo-liberalism and the financial crisis, but no techno-economic paradigm can function alone. It must be noted that the socio-political paradigm is incompatible with the new techno-economic paradigm, and what is needed is a revolution in the political paradigm of a new society rather than just another technological revolution (Lundvall, 2017). Similarly, Dosi believes that any technological advancement is neutral. A technological revolution in any given field usually has two potential outcomes in terms of impact on the social structure. It can lead to technological feudalism and a deeply divided society, which is characterized by a monopoly of technological profits, or it can lead to a society in which the fruits of technological progress are shared among everyone. The type of social structure largely depends on how the policy is designed and how it guides. A series of social and economic problems, such as employment polarization and income inequality, have arisen since the fifth technological revolution. The fundamental reason is still the mismatch between socio-political fields and techno-economic fields (Dosi and Virgillito, 2019). Perez herself revised her opinions on the turning point and the reorganization of the system, stating that the turning point could last from 2 to 13 years or more. She believes the turning point depends not only on the dominance of financial capital over productive capital but also on the actions of governments. The technological revolution requires socio-political shaping by the government, providing an arena for new technologies to reach their full potential. The government should go beyond post-crisis financial regulation, and it should also include active intervention in income distribution and unemployment.

In Lundwall's view, the reason that biotechnology, which has been held in high hopes since the 1980s, has been unable to enter a period of large-scale explosion, much of this is due to the mutually reinforcing relationship between neo-liberalism and ICT, which has hindered

the deepening and diffusion of new technologies in the field of biotechnology. This actually shows that the efficiency release of the tide of the technological revolution is not affected by the existing social structure, social and political concepts and policies; at the same time, the process of its continuity will be constantly counteracted by the changing social structure, political system and ideas, forming a process of co-evolution. In particular, the emphasis is on co-evolution; however, rather than falling into the traditional formulation of "action and reaction," Lundwall and Dosi argue that when such co-evolution gets "locked in a trap," it can be broken through the initiative change of the social-political paradigm. "My conclusion is that politics and new forms of governance will matter more than the economy and technology for the eventual upswing and sustained economic growth a conclusion that might seem inappropriate and even surprising from someone with a life-long career as an expert on the economics of innovation" (Lundvall, 2017).

Although Lundwall proposed the concept of the social-political paradigm and Dosi emphasized the interaction between social structure and technological revolution, neither of them made a systematic exposition of the evolutionary characteristics and stages of the social-political paradigm, similar to those of the techno-economic paradigm. However, in regards to its specific content, it has obviously gone beyond the institutional analysis in the techno-economic paradigm. This paradigm includes analysis in the social and political fields, such as global governance, social mobility, social equity, ethics in science and technology, education and culture. Both Lundwall and Dosi realized that the gradual development of the techno-economic paradigm determined its interaction with the existing social structure and political order, which further formation and spread of the paradigm depends upon. The intrinsic energy of the great surge and its socio-economic influence are the result of the joint action of the socio-economic paradigm and the techno-economic paradigm. It is necessary to correct the unbalanced result of "feudalism" in the process of techno-economic paradigm by social-political paradigm. The socio-political paradigm has an obvious guiding and framing effect on the structure and potential release of the techno-economic paradigm, and the coupling of the two is the key to avoid the "problem-ridden present." The key criterion to evaluate the coupling performance of a socio-political paradigm and a techno-economic paradigm is whether the matching of the two can release the economic efficiency of the technological revolution at the same time and realize the "share" of the technological progress benefits.

Although the socio-political paradigm is still at an initial conceptual stage, it is an important add-on to the theory of the techno-economic paradigm, and it marks a breakthrough of the neo-Schumpeterian institutional analysis. It suggests that technological shift has not only an inherent economic logic that can form a techno-economic paradigm but also an institutional bias that will affect the direction and nature of the shift and therefore induce a self-reinforcing effect of technology and system, which will further affect the continuity and direction of shift. In Perez's techno-economic paradigm, she only discussed the alternation of new and old industries, financial capital and production capital. Perez mentioned no game, confrontation and compromise between different parties and no change of social structure. Her analysis on institutional inertia and institutional competition is highly abstract, and the technology surge is regarded as non-national and even inclusive, which does not involve national competition, rise and fall. Therefore, although neo-Schumpeterian economics has been emphasizing the co-evolution of technology, economy and society since Freeman, each subsystem is still endowed with relative opposition until the theory of the techno-economic paradigm. Before that, the initial germination of the technological revolution and its final performance are only described on an economic level, and the social structure and political ideas have been relatively disregarded.

The necessity for adaptation in the socio-political sphere is partly due to the fact that the release of the potential of the technological revolution itself requires the support of the socio-political sphere. As the revolutionary changes in technology have directional uncertainties,

policy support is needed to mitigate risks. Appropriate policies will also help channel and stimulate this release through measures such as the provision of infrastructure and overcoming institutional barriers. In the process of gradual release and diffusion of the technological revolution, a series of structural changes in the economic sphere also require the adaptive adjustment of social and political systems in order to maximize the potential of new technologies. On the other hand, the negative consequences of the techno-economic paradigm, such as distribution inequality, unemployment and ethical conflicts, also need to be alleviated and eliminated by institutional adjustment in social and political systems. The role of adaptation and facilitation in the social and political fields runs through the whole process of the surge. Whether a "great surge" brings about an era of problems or an era of prosperity much depends on the ability of societies and governments' adaptive flexibility to realize the enormous transformative potential of the technological revolution. For example, in the third technological revolution, the systematic reformation in the education and training system in the United States of America and Germany provided a large number of engineers and skilled workers for new industries at that time. This is widely recognized as one of the main reasons why the USA and Germany succeeded in catching up with the UK in this revolution. In the fourth technological revolution, the USA adopted infrastructure investments, taxes and social security, antitrust regulation, safety standards, free public education and publicly funded scientific innovation. This not only helps steer the effectiveness of the surge but also helps avoid the destructive impact generated by it.

The coupling of socio-political paradigm and techno-economic paradigm is essentially another expression of adaptation, adjustment and facilitation of productive labor, production network, economy base and superstructure. The standard of coupling between the socio-political paradigm and the techno-economic paradigm is to achieve the inclusive sharing of technological advancement profits while maximizing its economic value. This standard is really about whether a production relation shift and a base and superstructure change ultimately adapt to and facilitate the development of productivity. Lundwall's perspective of the socio-political paradigm is relatively creative compared with Parez's paradigm, as it discussed the base and superstructure, which no neo-Schumpeterian has included before. From a historical materialism point of view, the "problem-ridden present" was not directly caused by ICT's contribution to the financialization and acceleration of inequality but rather by the lack of proper policy guidance for its directionality in the social and political field.

5. What is the socio-political paradigm of the digital economy era?

What kind of socio-political paradigm is needed in this digital economy era? This requires a review of the digital economy's impact on the existing social and economic structures. The new generation of digital economy, represented by AI, big data and cloud computing, has new characteristics, which are different from any previous technological revolution. For technical characteristics, this new generation of digital economy can easily support modular production, space reduction of production and exchange and labor replacement through automation and machine learning. This characteristic implies that, first, the modular production formed since the information technology revolution will be given new content, i.e. automated, intelligent modular production, which not only leads to the restructuring of the global production chain but also a restructuring of the global labor market. With the proliferation of robofacturing leading to automatic production, this would greatly reduce the scope for developing countries to absorb surplus labor through participation in modular production. Second, with the extensive use of 5G, virtual reality (VR) and augmented reality (AR) technologies, the service industry, especially face-to-face services, will become feasible in a situation where producers and consumers are spatially separated (OECD, 2019). This means that the geospatial constraints that limit the globalization of traditional services will

no longer exist, and such services could be globally deployed. Third, the use of AI in conventional cognitive work will not only replace traditional jobs based on standardized data such as lawyers and finance positions with "white-collar robots" but machine learning will also replace traditional scientific research based on trial-and-error experiments, i.e. mechanized knowledge production. If the first digital economy, symbolized by the Internet and the computer, simply led to the polarization of jobs – the explosion of both the high-tech labor and low-end service jobs and the diminishing of middle-skilled work positions – the new generation of digital economy, represented by AI and 5G technology, will have a greater impact on the existing two poles. In short, the widespread use of a new generation of digital economy leads to not only a radical change of international production and trade's whats and hows but also a dramatic change in the way in which labor flows and the job market. From the feature of production factors, the core production factor of the new generation digital economy is data. From production data to daily living data, the former supports smart manufacturing, while the latter facilitates various types of platform-based daily services. Data are characterized by reusability, zero marginal cost of reproduction, strong economies of scale and network effects. However, there is an inherent contradiction for data utilization. On the one hand, capital always has the tendency to strengthen their data monopoly, and data production possesses the path dependence and the beehive effect, i.e. the more we use and "contribute" data to a platform, the easier it is to stick to the platform and continue to use and "contribute" data, which makes it easier to monopolize the data. On the other hand, data can only achieve its economies of scale and network economy effects by maximizing sharing. Whether it is industrial production data or consumption data, only the comprehensive use of multi-dimensional source data can produce the greatest social welfare through the data scale effect and network effect. The contradiction between data monopoly and data sharing means that capital can more easily control workers and consumers through data monopoly and implement strict digital control, tracking and monitoring in the production, service and consumption processes. Not only is capital not required to provide data, but even the investment costs for production materials and labor tools can be apportioned among and provided by workers, forming what is known as Turbo-Taylorism. On the other hand, this kind of contradiction means that society cannot get the efficiency optimization and welfare improvement of data sharing, although data sharing and data opening will also allow data monopoly capitals reach to higher comprehensive utilization efficiency; however, this sharing and opening will weaken its market position and lose its control over workers and consumers.

The characteristics of technology and factors of production in the digital era require a new socio-political paradigm to cope with. In view of the technological and other essential features of the new round of the digital economy, the social governance and policy dilemma exposed in the ICT era will not be alleviated in the AI era but will likely be further aggravated. Recent open legislative discussions about the Robot tax, Bit Coin tax and AI algorithms are a social policy response to the new digital economy. In the long run, the new round of the digital economy will inevitably have a huge impact on income distribution, labor-capital relations, industrial structure and mode of production organization; therefore, the policy guidance should be considered comprehensively from many aspects including tax legislation, labor relations, social equity, social mobility and so on. However, across a wide range of policy areas, there is a particular need to focus on data governance and labor relations. As the goals for a benign coupling of socio-political and techno-economic paradigms are to release rather than contain technological potential and share rather than polarize technological benefits. Therefore, in the direction of social and political policies, on the one hand, we should start with data governance through the establishment of property rights systems and tax systems related to data elements, as well as the construction of data standard systems and data security systems, improving the network and scale effects of data

elements to encourage innovative data production and use while avoiding data monopolies. On the other hand, drastic adjustments to the labor market may be required. The government should prepare for a buffer between investment in education and employment and redistribute the benefits of technological progress through income policies. While implementing active employment policies such as lowering the threshold for entrepreneurship, providing tax incentives and systematic education, training and re-skills measures, there is also a need to guide and supervise involuntary part-time work and non-standard forms of employment contracts to protect workers' rights and interests. In times of major labor market shocks and social instability, it is necessary for the government to implement Minsky's Employer of Last Resort (ELR), particularly through increased hiring in the public service sector. Since the new round of digital economy will lead to the global and trans-regional distribution of service workers, it is particularly necessary to establish an effective and long-term international governance and coordination mechanism, which is the focus of the new round of socio-political paradigm, and it is also where the challenges and pressures are most concentrated and most formidable.

In the process of the new wave of technological revolution, the cause and internal mechanism of the "problem-ridden present" deserve our vigilance and attention, and the necessity and importance of the coupling of the socio-political paradigm and the techno-economic paradigm also has the obvious enlightenment value. The rise of the sixth technological revolution, represented by AI, big data, nanotechnology and biotechnology, suggests that profound changes will take place in the social patterns of labor production and economic activities. How production activities are organized and surplus production is distributed will also be different from previous times, which will inevitably bring about adaptive challenges in the social and political fields, and therefore concepts, norms and policies in the social and political sphere should also adapt. As Dosi points out, at present, human society is facing a historic juncture of technological development and socio-economic organization, which can possibly lead to some form of technological feudalism and a severely divided society but also has the potential to transform into a society where the benefits of technological progress are shared. The ultimate outcome largely depends on the policies we design and implement.

6. Conclusion

Since the 1990s, the research on long-wave theory has been concentrated in two directions: one is the neo-Schumpeterian, which inherits the tradition of Joseph Schumpeter's innovation; the other is the traditional Marxist school of social accumulation and adjustment (Gutiérrez-Barbarrusa, 2019). In the neo-Schumpeterian school, the theory of the techno-economic paradigm of Perez, Freeman and others is regarded as the most representative long-wave theory, and it is also seen as a feature of the institutional analysis of the neo-Schumpeterian. After the financial crisis in 2008, not only the theoretical hypothesis of an "introduction period financial crisis" in the techno-economic paradigm was challenged, but the mutual reinforcement of information and communication technology revolution and financialization has also made the economic and social performance of the fifth technological revolution different from that of the previous technological revolutions. Neo-Schumpeterian scholars, such as Lundwall and Dosi, came up with the concept of the socio-political paradigm, which states that the coupling process of socio-political paradigm and techno-economic paradigm is accompanied and determined by the unfolding process of a technological revolution. With the introduction of socio-political paradigm, the neo-Schumpeterian got rid of the suspicion of technological determinism, and its long-wave theory became a real institutional technological co-analysis. The coupling relationship between the techno-economic paradigm and the socio-political paradigm is of great significance for understanding the new wave of technological revolution represented by the digital economy.

Notes

1. As time goes by: from the industrial revolutions to the information revolution C Freeman, F Louçã, - 2001 - Oxford University Press.
2. 新插入引文 Geels, F.W., Schot, J., 2010. In: Grin, J., Rotmans, J., Schot, J. (Eds.), Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change. Routledge, London; New York, pp. 9–101.

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