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# PRESENT AND FUTURE IN THE MIRROR OF THE PAST

## Capitalist Dynamics, Digital Technology and Industry in the Fifth Kondratiev

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**Abstract:** Global capitalism has entered a long downswing that started with the outbreak of the financial crisis in 2008. A debate has been opened about the causes of this slowdown, the prospect of a recovery and the role played by technology. The first point to observe is the character of the preceding long upswing. We argue that Fifth Kondratiev upswing was unstable and shortens by several weaknesses in the institutional framework. Given that weakness digital technology spread unevenly across even in the US economy, and the impact on productivity was limited. A huge excess of capital was the results of that forces mainly after 2000, driving the global economy to the financial crisis and then to global recession that still persist, in spite of the lender of *last resort*. At this point the prospects of recovery depend on the extension of digitization to a new level often called Artificial Intelligence. However, this new level of digitization will imply a deep impact on social relations in general and specifically in labor relations. A disturbing feature of the present time is the role played by digital monopolies that control the passage to AI. The only way to counteract that power is by a new social pact at global level.

**Keywords:** technological change; economic growth; productivity; digital monopolies

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## Introduction

World capitalism is in a Kondratiev downswing that started with the outbreak of the financial crisis in 2008. Since then, having passed almost 11 years, the expected recovery has not been achieved. It could be argued that, despite the weak growth, the average real world GDP rate has experienced a modest improvement in recent years, but it is an illusory situation, since it is growth induced by extraordinary measures to stimulate demand and relief from over-indebtedness, derived from the monetary facilities implemented by the central banks of the United States (US hereafter), the European Union and Japan. Despite the anti-recessionary measures, the economic depression appeared at the end of 2011, which led to the re-launching of the monetary facility program and the repurchase of real estate and corporate bonds. We are then in an economic depression mitigated by the intervention of the lender of last resort.

This economic depression, converted into a global recession, has certain characteristics that give it its historical specificity with respect to the other two depressions previously experienced by capitalism (the late nineteenth century and the 1930s). The current technological system, from which the capitalist dynamism emanates, that is, Information and Communication Technologies (ICTs), are relatively young and have strengthened their potential by having been translated into a generic technology: digitization and networks. However, the *Fifth Kondratiev* ( $V$ - $Kv$ ) upswing was unstable and the average growth rate did not reflect the underlying technological potential.

On the root causes of the performance of capitalism in recent decades, as well as the specific role of technological systems, a broad debate has been opened; there are also research lines with little or no communication between them. In a general sense, it is debated whether the period that we have characterized as the  $V$ - $Kv$  is part of a broader trend of secular descent in the growth rates, especially in developed countries. It also discusses whether the current technological systems have reached their phase of exhaustion prematurely (techno-pessimism) or, on the contrary, maintain their potential (techno-optimism). The previous discussion is about the technological leadership of the US, which for some reasons has weakened before other powers, with unequal impacts on the diffusion of technology.

Based on Marx's approach, it is pointed out that the average rate of profit has experienced a sustained decrease, which obviously implies a decrease in the rate of long-term capital accumulation. It is argued that the counteracting forces, especially the increase in productivity linked to digital technology, have not acquired sufficient strength to relaunch capital accumulation.

On the second debate, that is, if we are in a phase of exhaustion or contrary to technological flourishing, several arguments are advanced. Techno-pessimists

stress the slowdown in the growth rate of aggregate productivity that has spread for several years, forming a long-term trend. According to Robert Gordon (2016), the total factor productivity grew between 2004–2014 at a rate of 0.4% per year, less than half the annual rate corresponding to the most favorable period, from 1994 to 2004, of 1.03%. These data coincide with updated information from the World Bank and the International Monetary Fund, although it is noted that the US has experienced some recovery in recent years, while the European Union worsened.

For Gordon the drop in productivity and, therefore, a supposed shortening of the Third Industrial Revolution (*III-IR*) is due to the fact that its central system, information and communication, exhausted its potential to boost economic growth; but developed countries, faces another headwind: the decline in the population rate growth (Gordon 2014; in a similar sense Piketty 2014). We will refer to the topics mentioned about in last section. The reply to this argument comes, among others, from Brynjolfsson and McAfee (2016), who strongly argue that digital technology is at its height and constitutes the sustenance of the “second machine age.” In a similar perspective is Klaus Schwab (2016), stating that the fourth industrial revolution centered on artificial intelligence (AI) is emerging and imminent. We could add Carlsson (2004) in this group, as he conceives digitization as the most powerful generic technology known to date, attributing him enormous potential to boost economic growth.

An intermediate position in this controversy is that of the McKinsey Global Institute (2015), recognizing the adverse outlook in terms of aggregate productivity, but attribute it to an inherent property of the new technological systems: it would be a form of creative destruction, which they conceptualize specifically as digital disruption. To the extent that the applications of digital technology represent a new way of doing things, they point out, it is associated with the destruction of value (generated by traditional companies), at the same time as new value is created (by new firms). The first magnitude is for now superior to the second, sustains the aforementioned study; hence, the adverse repercussions on several aggregate indicators of economic performance.

Regarding US technological leadership, the idea that its potential has been diverted to platform systems (*e-commerce*, social networks) implied it has progressively lost control over the base links of TICs, such as the software and semiconductors, which have been dispersed in several countries. However, there is contrary evidence that the science and technology system and the Silicon Valley corporations confer on the US the technological leadership although, as Kai-Fu Lee (2018) points out, this domain can be modified as a result of the race for AI. We will see that question in the last part of the article.

To sum up: the three debates are related so that the hypothesis of the long-term decline in profitability is combined with the growing competition facing

the United States in key segments of TICs. Counter-argumentation is also articulated on these three levels: thanks to the enormous potential of digital and networks technology, capitalism would be on the threshold of a new era of dynamism that would allow extracting the maximum fruits of digitization even under American leadership.

Both sides of the debate have recoverable elements, but in the middle remain several issues insufficiently specified and clarified. In effect, the rate of capital accumulation has declined in compared to the Golden Age (from the 1940s to the 1960s) but capitalist wealth has increased dramatically in recent decades, causing perplexity and alarm, while placing the social inequality at the center of a broad debate (see Piketty 2014).

Looking in retrospect, there is a disquieting similarity between the *Belle Époque* and the period that began with the 1980s. Both are characterized by an abysmal concentration of income, but also by the emergence of new technological systems. This leads one to think that the problem is not in the technological system itself, but in the precarious *V-Kv* socio-institutional framework. Due to the above, there has been a high concentration of the fruits of technology and the industry in the hands of a few, the best informed and well connected. These agents thus become the most powerful fraction of the capitalist class.

In a previously article (Rivera, Lujano and Garcia 2018) we discussed that crucial relationship between the paradigm or technological system and Socio-Institutional Framework (SIF), that modulate the latter. In that article it was explained that the social adoption of a technological system with pervasive effects (generator of creative destruction) requires a set of rules to define the balance between winners and losers. This framework which Freeman and Pérez (1988) defined as SIF, can be minimal, in which case the phenomenon of the “winner takes it all” occurs, typical of liberal capitalism at the end of the nineteenth century. This minimalist SIF prevailed by inertia in the interwar period.

After the hecatomb of the interwar period, the SIF was redefined as a means to balance the distribution between capital and labor, so that social pacification would contribute to a more stable and lasting growth, while preserving the integrity of capitalist relations of production in the face of external threats: the emergence of Soviet communism.<sup>1</sup> In the aforementioned article we return to the concept of “coupling” that occurs when the technological system and SIF are related in such a way that the balance of the distribution is achieved. As Robert Boyer (1988) explained by using a related concept of “mode of regulation, a broad spectrum of actions is required to achieve equilibrium in class relations in order to boost capital accumulation.<sup>2</sup>

To this point we are in condition to consider the relationship between the nature of *V-Kv* and by extension to the prospects of extension or, on the contrary, the

overcoming the global recession. To achieve this it is necessary to see the present (and the future) in the mirror of the past, adopting three guidelines:

- (a) The relationship between technology and capitalist dynamics follows the logic indicated in the previous paragraph, so that in each industrial (or technological) revolution emerges a specific SIF.
- (b) Each phase of capitalist development depends on a new source of productivity as Castells (1996) argues, which source is socially modulated technology. The distinctive feature of the current phase, or its long-term wave, is that the source of productivity lies in what Castells (1996) calls *informationalism* (processing of information in the form of bits, that is, binary digits) with a weak SIF associated to distributional imbalance as explains.
- (c) ICT have the characteristics of a complex system that has followed a trajectory constituted by the successive recombination of its elements, which in principle increases its power as a generic technology emerged extending its impact in whole socio-economic system.

Therefore, it is necessary to distinguish, in the trajectory of the digital system, three stages and a fourth in the embryonic state. The first phase corresponds to the stand-alone computer, put at the service of information processing of the most intensive data management activities such as airlines, insurance, banking and commerce (Gordon 2016). The second stage corresponds to marriage of computer and communications through internet (Gordon 2016). The third corresponds to the emergence of the Global Digital Economy, which adds to the networks the ecosystems of users and suppliers with superior organizational forms, the so-called “digital platforms.” The stage in progress is based on big data, analytics passing to *machine learning* and pointing to the autonomous digital systems, that is, AI.

Each of these phases represents a moving target in terms of social regulation of technological systems in the sense explained above; in this way, socio-institutional lags become cumulative, tending to diminish the potential for growth derived from technological systems, since the *first movers* pose high barriers to entry and begin to dismantle the productive bases of traditional industries to rebuild them digitally the imbalance in the distribution tends to increase the glut of capital, generating cyclical instability; we will refer to this last point later.

The hypothesis that emerges from the above can be stated as follows: the technological system associated with the *III-IR* is very powerful and has a great potential that has not yet been exploited. The problem is that the social pact that has been woven around it broke the capital-labor balance of the Golden Age, and then the benefits tend to concentrate in favor of the holders of capital assets, specifically, of *big capital*. This SIF, instead of promoting a steady capitalist

accumulation, shortened the growth cycle and made it unstable, with two severe crises (2001–2002 and 2007–2008) that finally led to an economic depression attenuated by the action of the lender of *last resort*. The idea that digital technologies have been exhausted is ill-conceived, since it implies confusing exhaustion with disruption. In the US, the world technological leader, ironically the diffusion of digitalization is very uneven, meaning small and median firms suffer smaller margins of profit and wages has been stagnated for the whole period. In contrast the advanced agents, that we will call the great digital capital (or *BigTech*) exert control on markets, taking the biggest share of global profits and are also capable of influencing the pace and direction of the passage to the most advanced form of digitization: AI.

The article continues below with a debate about the rate of profit, focusing on the concept of *big capital*, in order to find a solution to the paradox of a falling rate of profit that co-exist with an extraordinary concentration of wealth in very few agents. In this section it is central to evaluate the role of technology and digital systems in distributive issues. In the following section, an alternative theoretical framework is proposed to clarify the relationship between technological revolutions and industrial revolutions in reference to the digital era. The final section aims to define the historical specificity of the *III-IR*, focusing on the socio-institutional factors in the passage of the *V-Kv* upswing (first level of digitization) to the *VI-Kv* downswing (second level of digitization).

## Declining Rate of Profit and the Phase of High Capitalist Profitability

There is recognition among Marxist and non-Marxist scholars that the average rate of profit has shown a downward trend in the very long term to the present day. However, factual evidence collected and widely discussed in recent years indicates that the decline in the average rate coexists with other trends that have observed since the 1970s: (a) an increase of stocks of capital, or private wealth as Piketty (2014) calls it, which means (b) an increase in the participation of profit in national income, plus (c) the ever bigger profitability of the big corporations in the world. As we said we are faced with an apparent paradox that needs to be resolved in order to move towards the problems of growth in the *V-Kv*.

Among the scholars that start from Marx (1946) estimating the downward trend of the average rate of profit are Esteban Maito (2014) and Alan Freeman (2019). Other scholars such as Roberts (2016) validate the data and analysis of Maito in his study of the most recent phase. Among the non-Marxists, Piketty (2014) points out that between the end of the nineteenth century and today the average return on capital has declined. On the other hand, Dumas (2010) adheres to the wide current

of Keynesians who emphasize the existence of increasing excess of global saving resulting in the decrease of the rate of return of the capital. Below, we will see roughly the estimates of those scholars, and then we will refer to the “paradox.”

Maito takes up Marx (1946, vol. 3) when he points out that the tendency of the rate of profit to fall is due not to the absence of technological advances but, on the contrary, at its increasing rate, because it causes the relative decrease of variable capital, in comparison of constant capital, that to say, the long-term increase in the organic composition of capital, lagging behind the rate of surplus value. Quoting Grossman, Maito (2014, 4) points out that “the counteracting forces, written by Marx in chapter XIV of the third volume of *Capital*, transform the trend downward into temporary crises, which implies that the accumulation of capital does not occur continuously, but follows a cyclical behavior.”

Instead of taking Grossmann point of view, Maito (2014) presents us a data to prove the steady fall of the rate a profit since late nineteenth century, and first of all emphasizes that the tendency is not explained by the increase in salary costs. Marx (1946, chapter XXIII, volume 1) made clear the role of the reserve industrial army, whose constitution allows the capitalists to consolidate their control of capital accumulation. Therefore, the increase in wage costs in periods of high accumulation only has cyclical effects by reducing the rate of profit, it causes the rate of growth to decrease and moving the economy into a recession. As for the calculation, Maito estimates the average rate of profit not from the total capital advanced, current and fixed, but only the latter. This is explained by the difficulty in estimating the annual rotations of the capital used (see Figure 1). In assessing the relevance of this calculation, Maito (2014) points out that the key to explaining the decline trend is the product/capital ratio, that is, the capacity of capital to generate new value.

Regarding the trend, we will focus our attention on the aforementioned Figure 1, which refers to developed countries. It is noted that the decline is sustained from 1860 until the crisis of 1929. It is followed by a moderate recovery that extends from the early 1930s to the mid-1960s. Then, in the last period that coincides with the  $V-Kv$ , this is, from the beginning of the 1980s to 2007, the average rate stabilizes, which is equivalent to partial recovery, since the average rate went from 10.8% in 1982 to 14.6% in 2007 (Maito 2014). However, as can be seen in the figure, the percentage of 2007 is almost half that of 1943.

The behavior of the rate of profit in the last period has sparked some debate, since the data suggest a slight and limited recovery since the 1980s, an observation emphasized by scholars such as Duménil and Lévy (2002). While the research of Alan Freeman (2012, 2019) suggests that the fall of the average rate in recent years has been underestimated, due to failures in its measurement.

According to Alan Freeman (2012), if only the fixed capital is used as the denominator in the estimation of the trend of the average rate, the decrease



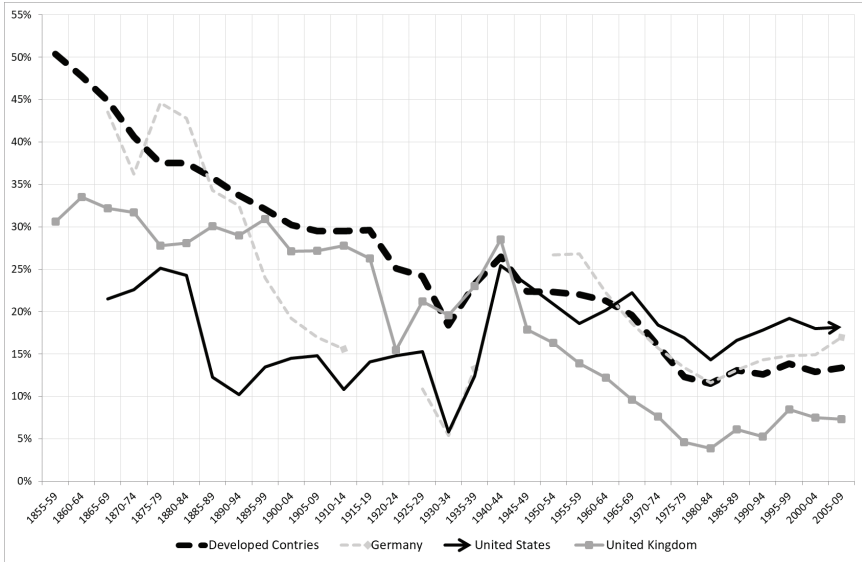


Figure 1 Average Rate of Profit in Germany, the United States and the United Kingdom, 1850–2010 (%)

Source: Maito (2014, 156).

experienced in the most recent period is underestimated. For this author, the issuance of financial assets by companies and their commercialization in the market at a certain price or interest start claiming a growing share of profit, to the detriment of productive investment. Thus, from the end of the 1970s until 2008, the stock of financial assets by the corporate sector increased steadily, a phenomenon known as *financialization* (Freeman 2012). While these assets in the hands of companies function as capital, they enter into the equalization of the average rate of profit, while the capitalists pour their capital into productive or financial assets to generate profits, otherwise they would cease to be capitalist (Freeman 2012). In this regard, Figure 2 (from Freeman 2012) indicates that the difference between the “traditional” and the extended calculation (including financial assets) is close to 12%.

The recognition of the general fall of the rate of profit goes beyond the Marxist circle. Charles Dumas (2010) points out that a characteristic of the period that began in the 1980s is the structural decline in the rate of return on capital. This phenomenon is related to what he calls the “shock of globalization” that meant a structural change in the world with initially increased investments, technology transferring and markets opening in China, India and a handful of other emerging

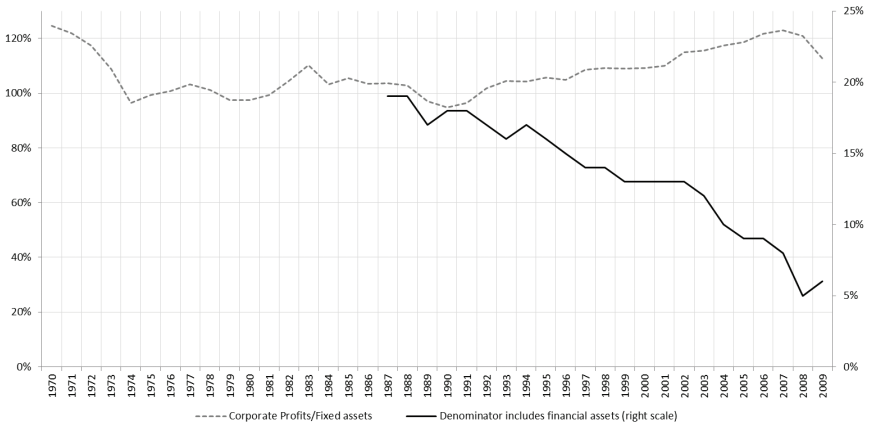


Figure 2 UK Earnings Rate, Traditional and Extended Measurement, 1970–2009

Source: Freeman (2012).

countries (Dumas 2010, see introduction). That process increased the value of capital assets (especially stocks and real estate) but several obstacles appeared to limit the use of capital resources productively, so that after the crisis of 2000 began a dramatic growth of excess of saving in the form of financial surplus of companies and the trade surpluses of the large Euro-Asian exporters (Dumas 2010, ch. 3). The excess of savings, Dumas (2010, 88) emphasizes, derives from a deficiency in demand, reducing the rate of return on capital that has continued even after the financial crisis. As noted, except for the conceptual differences and the interpretation of the specific role of the US, there is a coincidence as the Marxist scholars quoted, at least for the period beginning in the 1980s not only in the trend, but in the consequences, as far as the structural excess of saving is a burden for a possible global recovery (Dumas 2010, ch. 4).

On the other hand, we now will see the analysis and estimates proposed by Piketty (2014). He studied long-term capitalist profitability since the nineteenth century, mainly in developed countries. Piketty (2014) focuses on three variables: (a) stock or assets of accumulated capital (capitalist wealth) measured as years of national income; (b) the rate of return on capital ( $r$ ), defined in a similar way by Marxist scholars such as Maito (2014), that is, the capitalist benefits divided by the stock of capital; and finally, (c) the participation of capital and labor in the national income.

Given the importance of the relationship between accumulated capital/national income, let's look at his definition of capital. In the book's introduction, Piketty defines capital as the set of tradable assets, which includes buildings, equipment,

machines, patents, stocks, bonds, other financial securities, but also real estate, even if the residents are salaried (Piketty 2014, 60). The ratio between capital stocks and national income shows a very clear trend in developed countries, says Piketty; for the European powers it starts at a high level at the beginning of the nineteenth century, about seven times, but steadily drops until the 1920s and the immediate post-war period, rising again to almost six times after 1990 (Piketty 2014, ch. 3). In US the behavior of this relationship is more stable, being between four and five times between the end of the nineteenth century and the 1930s; after a decline in the 1940s, it rose to just over four times at the beginning of the twenty-first century (Piketty 2014, 176). As can be seen, there is a great coincidence in the quoted scholars since they see that the stock of capital tends to increase.

Regarding  $r$ , Piketty (2014, 226–228), estimates that on average it has declined from the nineteenth century to the present, going from 4.5 to 3.4%, affecting mainly those he named “small rentier.” By pointing out that  $r$  tends to decrease over long period, Piketty agrees with Marx. Concerning the causes Piketty (2014, 234) stress two: (a) technology, or the productive uses of capital, and (b) the relative abundance of capital. Both factors are related, because if the productive uses of capital expand it will less abundant and it precisely the abundance of capital that “kill” profit. How strong can the impact of that abundance of capital on  $r$ , Piketty asks himself; he responds that it depends on the range of available technologies that determine the substitution of labor for capital, which is proposed to be estimated through the respective elasticity of substitution, which will be greater or less than one. Piketty (2014, 244–245) points out that from the historical data can be estimated with great caution “an elasticity between 1.3 and 1.6%,” which means that still there are alternative uses of capital, which attenuates a greater decrease of  $r$ .

Piketty (2014, 191) emphasizes that the relative increase in stock of capital is mainly due to institutional factors and the correlation of forces, specifically: (a) the transfer in very favorable terms of public assets to private hands and (b) the revaluation of property real estate and capital, but above all stock market prices, which coincides with what was pointed out by Dumas (2010).

What is the Piketty’s conclusion about the trend of capitalist profitability? Capital is currently less productive but having increased the value of stock of accumulated capital in recent decades, capitalists have a larger patrimony and receive a larger share of national income. As we saw, a limitation of this analysis is Piketty reluctance to accept that excess capital is implicit in the increase of national capital/income assets and that his estimate of a substitution elasticity slightly above 1 is a mere conjecture.

We have clarified the apparent paradox, especially because of the role played by institutional factors. However, it is necessary to add two additional factors

related to digital technology that are impacting profitability in different directions: (a) capital good based on digital technology has had a strong capital-saving effect, since it has exponentially reduced performance-adjusted prices (Gordon 2016), which feeds the excess of capital and depresses  $r$ ; (b) in the absence of comprehensive regulation, digitalization promotes monopoly through network effects, a property similar to natural monopolies, which determines the concentration of profits among the *first movers*. This brings us back to the concept of *big capital*, as predicted by Marx.

The concept of *big capital* is originally formulated in Marx's *Capital* (1946, chapter XXIII, section VII, vol. 1) where a derivation of the General Law of Capital Accumulation is indicated, that is, the increasing centralization of capital, which implies a redistribution of social capital, or what is the same, the expropriation of the smaller for the biggest and the concomitant increase in the minimal amount of capital needed to start a firm. In volume 2 of the *Grundrisse* (Marx 1971), Marx raised the concept of *big capital* under the figure of monopoly and defined it as a counter-tendency of fall of profit rate (Marx 1971, 284); in addition *big capital* is best placed to access to credit and restrict competition (Marx 1946, 779, vol. 1).

The centralization of capital and, therefore, the emergence of larger capital, is a process that began to emerge from the late nineteenth century, which accelerated with the spread of the joint stock company and the rise of the organizational form adopted by the most powerful capitals: the transnational corporation. The role of science and technology that began to gain strength since the early twentieth century encourages more centralization of capital. The rise of *big capital* has coexisted with a reduction in the profit obtained by small capital and rentiers due to the separation between ownership and control as suggested by Piketty. Hilferding (1959) systematically analyzed the previous trend and showed the dividend is a mechanism through which a mass of capitalists has reduced their share in the surplus value produced, since they are limited to obtaining a smaller amount than the one previously held by the active capitalist. The difference, which takes the form of founder profit, is transferred in favor of *big capital* (Hilferding 1959).

In the Golden Age the power of *big capital* or transnational corporate capital was consolidated (Ornelas 1995), but its financial bases were relatively weak, by virtue of the restrictions derived from the Welfare State. There is another feature of Golden Age: the pacification of classes based on the relative autonomy of the state, which implies limiting the power of monopolies and oligopolies through arbitration, applying strict anti-trust regulation. What is out of all controversy is that after 1970, in the  $V$ - $Kv$ , the state ceded its autonomy to most powerful echelon of capitalists. The above has two repercussions that should be analyzed at least in its central aspects: one, is what Mazzucato (2013) calls the *Entrepreneurial State*; the second

is the virtual absence of regulations to limit the market power of *big capital*, mainly digital giants or *BigTech*, as explained by Lina Khan (2017).

The research carried out by Mazzucato (2013) shows that after the 1970s, when the state was supposed to retreat to make way for supposed “private creativity” it was strongly promoting I&D through multiple actions, from the fundamental, as basic research in defense projects with civil applications, up to the financing of general and specific projects. The above means that the state followed after 1970 the same paradigm instituted after the launching of Sputnik in 1957, which led to the creation of DARPA (Agency for Advanced Defense Projects), whose mission included the promotion of innovative, long-term technological projects (Mazzucato 2013). The difference between the period before the 1970s and the period after, is, as Mazzucato explains, a change in the balance between benefits and risks, as we will see later. Thus, in pharmaceuticals in recent years, public intervention responded to a substantial decrease in private I&D expenses. Mazzucato (2013) points out that the National Institutes of Health in the US invests millions to absorb most of the costs for the development of drugs through clinical trials, while several pharmaceutical companies closed their I&D units.<sup>3</sup> The examples in nanotechnology point in the same direction. We will refer briefly to the case of Apple Inc.

Mazzucato (2013, ch. 5) explains that the scientific and engineering principles that support the *iPhone*, *iPod* and *iPad* and *Siri* originated in public laboratories, which the Cupertino company was able to identify and transfer them to products with a hugely attractive design (his real contribution). While Apple was focused on launching high-impact products, its research and development expenses as a percentage of its sales decreased, as did the payment of taxes and salaries. Mazzucato (2013) points out that the 12 main technologies integrated within the company’s flagship devices originated in public laboratories or financed with public resources. For example, in the case of touch screens, the advances made until the 1990s only gave the option to a single movement. The current design resulted from a project at the University of Delaware funded by the National Science Foundation; then the “iGesture Numpad” (Mazucatto, 2013, 109) was patented privately and was acquired by Apple as a start-up.

Regarding the balance between benefits and risks of state projects, Mazzucato (2013) points out that the great change is the US government (but also from European governments) decline to claim a levy on profit made by the corporations using those patents. Mazzucato (2013) emphasizes that to the extent that innovation activities are collective, that is, involve the participation of numerous agents of diverse origin, we have that the risks are socialized, and the benefits are privatized.

The *laissez-faire* in terms of technology transfer generated in public laboratories in favor of corporations is congruent with another huge concession to corporations. It is, as several scholars such as Khan (2017) explain, of the inoperativeness of the anti-trust currents laws, thus concentrating a huge market power in the hands of a handful of oligopolies and new monopolies. Khan (2017) explains that the above has its origin in the technology and digital systems that have impacted the industrial and market organization, which the US government and other countries have refused to recognize. Khan (2017) focuses on Amazon, but other digital giants such as Google and Facebook have structured their own strategies in the same principles (see Zuboff 2019). We will focus on Khan's (2017) article.

In anti-trust government agencies, an outdated doctrine prevails, explains Khan (2017). The traditional theoretical framework originated in the Sherman Act of 1890, defines the monopoly or oligopoly and other forms of collusion by its power to restrict supply and raise prices. The current studies on the *mark-up* show the tendency for the prices of digital goods to fall on average continuously. The question then is how these companies achieve their high profitability.<sup>4</sup> There are several strategies Amazon uses, and Khan explains one.

Amazon is not a traditional company, it is a platform or digital structure that accommodates an ecosystem in which various categories of users and suppliers (including rival companies) co-exist, which follow the logic and are subordinated to the priorities of the entity Leader (Khan 2017). By being able to act in this way, Amazon has several business personalities: retailer, commercial promoter, distributor, payment agents, lender, auctioneer, book editor, film and television producer, etc. This giant works in a downward price framework that currently prevails, but compensates for the above when integrating its business lines, which allows it to appropriate the data of other companies that are forced to integrate into its platform; that appropriation of data leads to tactics aimed to eliminate those real or potential competitors from the market. In the short term, prices on average decrease, but behind this there is a selectivity policy, in which lower and higher prices coexist. Once the competition is eliminated and the collaborators are subdued, it consolidates that market and begins to expand to others, lowering prices first. Therefore, the price-offer metrics do not account for the competitive status of a branch but a multitude of them that now appear intertwined. An alternative anti-trust approach, says Khan, would have to consider and evaluate: (a) barriers to entry to the sector, (b) conflicts of interest, (c) the appearance of bottlenecks, (d) use and control over external data, and (e) dynamics of bargaining power (Khan 2017, 746).

Let's see now how the above is translated into the profitability of *big capital* (Figure 3). Using the available *Fortune* Global 500 data (<http://fortune.com/global500>) that lists the 500 largest corporations in the world for their gross

income (before taxes), it can be seen that by 2018 the first positions are still controlled by giant corporations rooted in activities related to the Second Industrial Revolution (*II-IR*) (oil and automotive industry, with the exception of Walmart), however, see that *BigTech* tends to quickly gain more space. According to the classification of the same source cited, in 1995 only 16 of the 500 corporations belonged to ICTs (this includes manufacturing microprocessors, computers and other electronics, to design of software and internet services and digital information); 10 years later, in 2005 they total 24, by 2015 there are already 34 and finally in the list of 2018 they count 45 (about a tenth of the list of the 500 largest corporations). In contrast, the behavior of the profitability of the average US corporations in the generality of the measurements it is unfavorable and shows strong instability especially after 2000.

Let's compare between the stock capitalization of what we are going to call the big traditional corporations related to the *II-IR* and the *BigTech* of the *III-IR* (Apple, Amazon, Microsoft, Alibaba, Facebook and Alphabet) as shown in Figure 4. There is no doubt that the big winners, from the point of view of share capitalization are the corporations, while the traditional winners are clearly lagging behind.

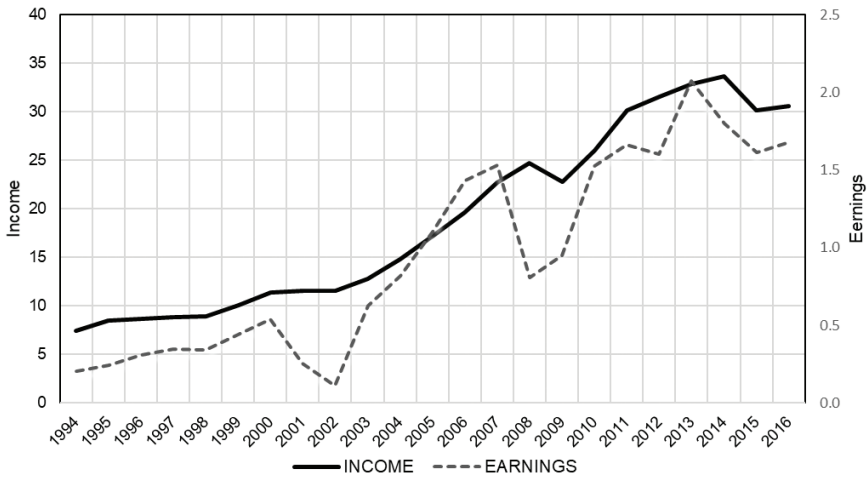


Figure 3 Gross Income and Net Profits of the 500 Largest Global Corporations, 1994–2016 (billions of real dollars, 2010)

Source: LET (2019).

Note: The LET presents information on the 500 largest companies in the world published annually by *Fortune* magazine. The gross income is before taxes and the net profits consider all types of discounts except for the payment of dividends.

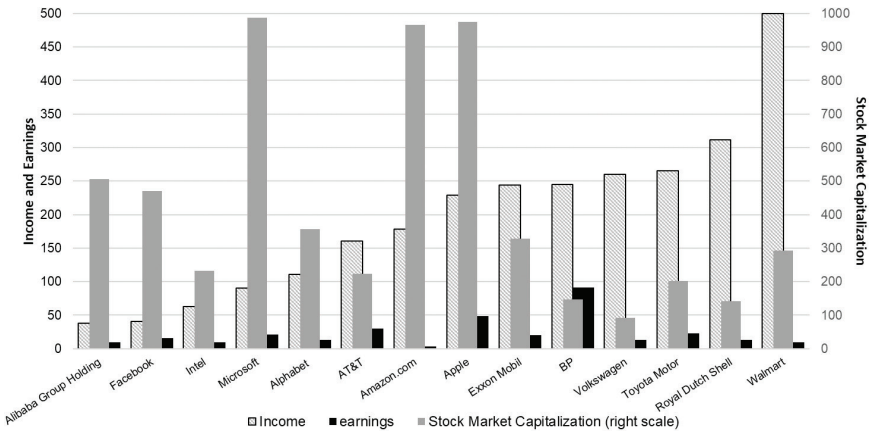


Figure 4 Behavior of BigTech vs Other Large Selected Corporations, 2017 (billions of current dollars)

Source: <http://fortune.com/global500>.

Note: Gross income is before taxes and net earnings consider all types of discounts except for the payment of dividends.

The 45 *BigTech* corporations represent 8.8% of the total gross revenues of the 2018 list (totaling 2.6 billion dollars), although their participation amounts to 14% if net profits after taxes (268 billion dollars) are considered. Another feature to highlight is the strong American technological leadership with respect to other competitors, with the United States being the country with the largest number of companies in the sector and with the greatest capacity for retaining earnings. This is corroborated in that 13 of the 45 *BigTech* have their fiscal headquarters in the US and have more than half of the total net profits generated in the sector (50.7%); in second place China appears with 8 corporations (11.5% of the profits of the sector), Japan also with 8 but with smaller participation in the total profits (8.8%), follow Taiwan with 6 (6.4%) and finally South Korea excels with 4 corporations (3 dedicated to electronics and 1 to semiconductors, but which account for 18% of the sector’s profits). Meanwhile, according to the same source, the European corporations have a smaller share with just four companies (only 3.2% of the profits of the sector): one German (SAP), one Finnish (Nokia), one French (Schneider Electric) and an Irish one (Accenture).

Another study corroborates previous trends regarding the distribution of global corporate profits in favor of the United States with strong level of concentration. The McKinsey Global Institute (2015) points out that the participation of global corporations from developed and emerging countries in real profits has



tripled in recent decades, going from representing 7.6% of global GDP to 9.8% of it. This study emphasizes that the distribution of these benefits is very unequal due to several factors; one of them is the growing participation of knowledge-intensive industries, to the detriment of capital-intensive industries. In addition, the corporations with the highest capitalization, that is, those with annual incomes over one billion dollars (which we can name also mega corporations), take the majority share since they concentrate 60% of the global income and represent 65% of the total capitalization of these entities (McKinsey Global Institute 2015). But what is blunter: a handful of these giants lead the creation of new value, so that 10% of them monopolize 80% of the profits and the top quintile 90% (see Table 1).

There are several factors that explain the high levels of profitability of *big capital*, especially those located in Western countries. Openness and liberalization policies have opened markets in several regions that were previously relatively closed; the tax rate on capital gains has been substantially reduced, especially in the US; to this must be added the formation of the global labor reserve army that has placed at the service of large corporations just over one billion new workers, first of low and medium qualification and then knowledge workers.

Table 1 Behavior of the Profits of Global Corporations, 2013

<b>A. Percentage distribution by regions and countries</b> <b>100% = \$7.2 trillion of dollars</b>		<b>B. Corporate benefits in millions of millions of dollars *</b>		
			<i>Net after taxes</i>	<i>Percentage of world GDP</i>
<i>North America</i>	26			
<i>Western Europe</i>	25	1950–1970		7.0%
<i>China</i>	14	1980	2.0%	7.6%
<i>Japan</i>	7	2013	7.2%	9.8%
<i>Latin America</i>	6	<b>C. Participation of US mega corporations in the global benefits**</b>		
<i>ASEAN</i>	5			
<i>South Korea</i>	2	<i>Percentage of corporations</i>		<i>Share in total benefits</i>
<i>India</i>	1	10%		80%
<i>Others</i>	14	5%		90%

Source: McKinsey Global Institute (2015).

Notes: \*With annual revenues of more than 200 million dollars. \*\*With annual revenues of more than one billion dollars.

As noted, the inclusion of large capital is essential to achieve a unified explanation of capitalist dynamics. That elite establishment is at the center of a re-engineering of power, which means that the capitalist state, above all, but not exclusively in the US, is at the service of the mega corporations; they tend to predominantly take control of technological change and the appropriation of their fruits after 2000 as explained by the cited scholars. The previous process has been ignored because the compression of the disruptive effects of digitization requires differentiating between technology as new useful knowledge and its productive applications, a process in which the correlation of forces is determinant, as we have seen. It is necessary, therefore, to carry out a conceptual review around the relationship of the previous concepts.

### **Alternative Theoretical and Historical Framework on the Relationship between Technology and Industry: The Role of Digitization**

As Brian Arthur (2009) correctly points out, there is no definition or theory of technology, although it is possible to identify or describe the specific systems (say the microprocessor or the turbojet) or explain their behavior or their history. Even Arthur refuses to give a direct definition of technology because he says it does not exist; rather he provides a key that is its evolution. The current systems are the result of a long evolutionary process of subsequent combinations of previous blocks, which together with the identification of new natural phenomena, gives rise to certain solutions or practical uses.

The notion of recombination proposed since the 1920s by the young Schumpeter to explain economic change (Arthur 2009), is fundamental as is the relationship with natural phenomena, but the link between this succession of recombinations and scientific knowledge is also crucial. To follow this link, we refer to Joel Mokyr (1992) because it will provide us with the key to the durability of a technological (or industrial) revolution, a central issue after the 2008 crisis.

Mokyr (2002), unlike Arthur, finds a common element and a specificity, saying that technology is a stock of useful knowledge. That conception was originally proposed by Kuznets (1973), but he identified formal science as the foundation of useful knowledge. Mokyr (1992) criticizes that the formal scientific component is only a part, minority or residual in the first industrial revolution; even in the second industrial revolution the participation of science is limited but tends to grow from the beginning of the twentieth century.

If formal science is only a part of useful knowledge, what is the complement? It is in that last point where the contribution of reveals its enormous relevance. Mokyr (1992) points out that to understand historical changes in production

systems it is necessary to differentiate two components of useful knowledge: (a) propositional knowledge, that is, sustenance or *why*; (b) prescriptive or applied knowledge consisting of a set of instructions for a practical purpose, *the how*.

The main sustenance of propositional knowledge is formal science; the second is explained by Mokyr (2008, 53): “Propositional knowledge contains more than formal science [the additional] ... it includes all facts and natural relationships, as well as a general catalog of all the techniques that are known to work.” That second stock was formed, says Mokyr (2008), with the Illustration and later developed to give rise to the scientific method, the scientific mentality and scientific culture.

Applications (sometimes referred to as technique) or the prescriptive part, emerge when useful knowledge is “mapped” into a set of instructions. Much of the knowledge that supports these instructions can be tacit or diffuse, but it has some effectiveness. The aforementioned transformation, adds Mokyr (2008), is social because the “mapping” implies the participation of several agents: the people who design and those who build the artifact are not necessarily the ones who possessed the necessary knowledge.

Below, Mokyr (2008) proposes the crucial concept of “epistemological basis” (especially the background understanding or formal science) of the propositional knowledge, which in turn serves as a support to the instructions or “technique.” Every technique, primitive as it may be, needs an epistemological base, even if it is minimal, that if materialized, allows the people involved to achieve a result, but they may not know why. In the aforementioned case, subsequent improvements will be more difficult if the epistemological basis remains narrow.

Then comes the dichotomy between macro-inventions and micro-inventions (Mokyr 1992); the difference between both derives from the epistemic distance (background understanding) and the stock of previous prescriptive knowledge. A macro-invention is one that cannot be considered an improvement of an existing technique, so that there is an epistemological discontinuity that extends the field of the possible. A case of macro-invention is the Newcomen machine (predecessor of the Watt steam engine), or the ENIAC computer. Then, according to Mokyr (2002), what is usually called technological advance or change in its broadest sense begins with the almost surprising appearance of a macro-invention, which results from a previous accumulation of micro-inventions.

However, for Schumpeter (1963) and his disciples the fundamental technological advance, the creative destruction or technological revolution, occurs not from the inventions, but from the constellation of innovations (array of new combinations). The definition of the latter, as is known, is relatively broad because it covers production system, new or improved products and opening of new markets. In short, in the current lexicon technology is in addition to a stock of useful knowledge, an application to processes and products and is associated with artifacts and

systems. This turn and amplification of meaning resulted in the eclipse of the notion of industrial revolution to be replaced by technological revolution.

For example, Carlota Pérez (2002) characterizes the technological revolutions as constellations of products and industries, as well as organizational principles applicable to mature industries, pointing out that when technology is translated into paradigm change, it creates new growth engines and elevates the productivity. That is why neo-Schumpeterians see technological change as the engine of economic growth.

But it is not just a change of terminology and amplification of meaning. The common interpretation among techno-optimists of considering what are strictly inventions as technologies of direct productive impact, such as Brynjolfsson and McAfee (2016) do. For Brynjolfsson and McAfee (2016) there are no cracks between the invention of the World Wide Web based on the old TCP/IP protocol of DARPA with the hypertext and Facebook and so on. What Brynjolfsson and McAfee (2016) underestimate is the long gestation period of about 30 years and role played by the “dot.com” crisis in 2001, that violently establishes the continuity between the network economy and the first digital platforms. For Tim Berners-Lee, its inventor, the web was a service for humanity (see Harvey 2015), but unfortunately that was distorted, which allows us to understand that it is not the same in commercial terms, the World Wide Web or Instagram.

Elsewhere we have criticized the interpretation that derives from the new terminology and the extensions of meaning: the one that directly relates technology to growth (see Rivera, Lujano and García 2018). In addition to the fact that inventions can give rise to unexpected innovations and therefore to potentially different productive trajectories, innovations have a degree or levels of maturity and the triggering event, or creative destruction, is rather a process that can extend for years and even decades; only later in retrospect can it be given a stylized interpretation, which can lead to confusion.

Supporting us of the concept alluded to in the SIF but modified by Tylecote (1992), we emphasized the importance of this social modulation of technology that serves as a conduit for its productive application. The central function of the SIF lies in balancing the participation of labor and capital in the value created, defining growth rates and the extension of the long wave or Kondratiev. We saw, based on Tylecote (1992), that basically there are at the limit two possibilities for a technology to be socially integrated and causes specific distributive effects: (a) that it evolves in a weak SIF coming from a weak crisis ( $V-Kv$ ); or (b) that it evolves in a strong SIF coming from a strong crisis ( $IV-Kv$ ).

The partial conclusion so far is that technological change can have various historical repercussions, depending on the degree of coupling and de-coupling (Freeman and Pérez 1988). So, the historical trajectory, that is, the technological

or industrial revolution will be a process of social search for that synchrony that takes several decades as we will see.

Therefore, it is necessary at this point to recover the aforementioned Pérez definition (Freeman and Pérez 1988) of technological revolution and we can see that she is talking about an industrial revolution, as stated above. An industrial revolution will not take place unless macro-inventions and radical innovations are verified; what must be emphasized is that what follows after macro-inventions is necessarily a prolonged process of social experimentation to find socio-institutional as well as industrial solutions.

Gordon (2016) recognizes the above when defining the industrial revolution, specifically the *II-IR*, as a prolonged period of almost a century, with a gradual improvement of the systems and products that goes from the discovery of electromagnetic properties, to the electrical dynamo and factory electrification, etc. The point of departure is not the one Pérez says, that is, the constellation of products and systems, but a preparatory recombination to that constellation that is progressing gradually and in a largely indeterminate way. In Table 2 we present the relationship of the different concepts and their periodization.

As it is noticed and will be explained in the third section, we will consider that the *III-IR* is still in progress because the propositional knowledge expanded considerably with the invention of the transistor, which resulted, from the 1970s, on enormous possibilities of recombination (that is, of the prescriptive mapping). Digitization and networking is a new recombination, but it follows another sequence, mainly artificial intelligence. In the above sense it is not relevant to talk conceptually of a Fourth Industrial Revolution. What is required is to differentiate the levels or recombinations of digitization, which is the unifying factor of the different stages of the industrial revolution in progress (*III-IR*). The second level of digitization (i.e., AI) has strong elements of continuity with the first level digitization that raised the levels of automation, but without converting those systems into autonomous.

It should be added that the industrial revolution as part of the transformation of capitalism, rather than a creative explosion, is a prolonged process of social experimentation that involves detours, dead ends and conflicts. The *II-IR*, as defined by Gordon (2016), took a century and went through two world wars and two economic depressions; but that does not mean that it is a metric and an invariable pattern, because each industrial revolution has its historical specificity, a relatively long process whose duration depends on several factors.

This framework of an Industrial Revolution as a long social experimentation proposed by Gordon (2016), comes mainly from David (1990) when comparing the electric dynamo with the computer, to achieve what he calls seeing the present and the future in the mirror of the past. In the same sense David (2002) and

Table 2 Industrial Revolutions and Technological Revolutions

<i>Industrial revolutions</i>	<i>Technological revolutions</i>	<i>Consistency of the socio-institutional framework</i>	<i>Kondratiev cycle</i>	<i>Source of productivity growth</i>
FIRST 1770–1870s TG: steam machine	1771–1820s Textile machinery 1829–1870s Steam, railways	Embryonic  Minimum, in favor of the owners	I-Kv 1780–1850  II-Kv 1845–1890	Materials and energy
SECOND 1870–1970s TG: electric dynamo	1875–beginning of the 20th century Steel, electricity and heavy engineering 1908–1970 Oil, automobile mass production	In formation but unstable  Solid. Bretton Woods and Benefactor State	III-Kv 1890–1948  IV-Kv (upswing) 1948–1960  IV-Kv (downswing) 1961–1982	Materials and energy
THIRD 1970–In progress	1971–1991 Microchip-PC First robotization 1991 Internet and digitization (ICT)	Dismantling the previous framework  Neoliberal globalization	V-Kv (upswing) 1983–2008 <i>1st level of digitization</i>	Information in bit format
TG: Digital electronic computer and digitization-networks	2001 Organization on WEB platforms 0.2		V-Kv (downswing) 2009–In progress <i>Beginning of 2nd level of digitization</i>	Information and communication networks
	2014 Incipient Artificial Intelligence	Fragmentation of the neoliberal framework		

Source: The delimitation of the III-Kv to the IV-Kv corresponds to Duijin (1983). The V-Kv is defined according to Freeman and Pérez (1988, Table 3.1). The delimitation between the first and second level digitization corresponds to Rivera, Lujano and Garcia (2018). The definitions of technological revolutions come from Pérez (2002). Gordon (2016) proposes a second stage of the III-IR that begins, with the World Wide Web, involving the unification between information (computation) and communication (networks).

Notes: TG = Generic Technology

Rosenberg (1976) analyze microelectronics. Later we will refer to the common factors that exist between the second and third industrial revolution, trying to emulate the retrospective exercise carried out by the aforementioned scholars.

The periodization of Gordon's industrial revolutions (Gordon 2016) is in a section of his book that he calls "inter-act." The first revolution (1770–1820), on which there is consensus on the causes and consequences is based on the steam engine and its derivatives, particularly the railway and the steamship, supported by the start of the replacement of iron by steel. For Gordon (2016) the second revolution, which condenses the inventions of the late nineteenth century (electricity and the internal combustion engine) extends from the 1870s to the 1960s, or almost a century. The maximum effect on the product per person and per hour worked, adds Gordon (2016), took place between 1920–1970, but especially between 1940 and 1970; in those decades, he adds, productivity continued to accelerate due to technological derivatives such as air conditioning, long-distance highways and commercial air transport.

Gordon (2016) dated the beginning of the *III-IR* towards the 1960s; we prefer to define the start in the decade that goes from early 1970s to early 1980s, with two very powerful interrelated systems: the microprocessor and the PC. The applications of these systems were in a very fluid terrain and supposed to flourish with the New Economy, in particular in the furor of the "dot.com" companies; instead it culminates in the 2000–2001 crisis, which violently establishes a new coherence.

Giving the reason to the techno-optimistic, the technological principles of digitization have a great potential for recombination, but their productive results are still uncertain. To achieve greater productive results and that the technologies become profitable, a continuous process of search and experimentation of products and processes is required, and their possible transformation into a new SIF.

Once the new technology is installed, to use the concept proposed by Pérez (2002) comes the long upswing of the *V-Kv* but it does not manage to boost the accumulation of capital as the *IV-Kv* did (in the Golden Age). The failure lies, as we have insisted, in the lack in-depth socio-institutional reforms. That is why the expansive cycle was relatively short and interrupted by ups and downs, as we will see in the next section. Certainly, during this period, the power of computation advances almost exponentially thanks to the improvement of semiconductors and the unification of information technology (the computer) with communication technology. However, the disruptive impact limited the possibilities for growth and accelerated the passage to the long downswing. Consequently, the boost to productivity is ephemeral and the decline in its pace has already been a fact since the early 2000s.

## The Historical Specificity of the *III-IR*: From the Upswing of *V-Kv* to Its Long Downswings

We will begin by placing the growth pattern of the phase that begins with the early 1980s in a broad historical perspective. If we start from 1983 (beginning of the global recovery and until 2007, year in which the long upswings end, we can see that annual GDP *per capita* growth rate is 1.6%. That rate is almost half that of the Golden Age (1950–1973), the most favorable period, which is 2.91%. However, the 1983–2007 period growth (1.6%) is higher than the very long-term rate from 1820 to 1992, which according to Maddison (1995) is 1.2% per year. Even between 1913–1950 world growth was lower, 0.9 (see Table 3).

What stands out is that the historical rate of expansion of capitalism is comparatively modest, so that the *V-Kv* represents a return to normality, as we see later, not only in relation to the historical rates of growth, but also for the role of the socio-institutional factors. In the above sense, the Golden Age is the exception, not the rule, in terms of global dynamics, but also in relation to the SIF. As Piketty (2014) rightly points out, the acceleration of growth like that observed in the Golden Age is only achieved exceptionally when a group of countries experience catch-up for several decades, affecting the world average. Indeed, the analysis of growth by regions in the 1950–1972 period reveals that the countries that closed the gap were firstly Japan (8%), Western Europe (3.9%) and Southern Europe (4.9%); on the other hand, the US growth rate fell to 2.4%, lower than the global rate (Table 3).

However, the historic growth rate of 1.2% should not be underestimated, since it is a cumulative rate that implies the compound interest principle, meaning that the accumulated wealth rises by about 40% in 30 years (see Piketty 2014, ch. 2 for deeper analysis). After almost two centuries of average growth close to a rate of 1.5% per year in rich countries, it is important to determine the distribution that prevails in developed countries between capital and labor.

For the period of 1983–2008 to be equated in growth rhythms achieved in the Golden Age, the following conditions would have to be met:

- Accelerated growth in a group of countries that experience catch-up and therefore raise the world average.
- That a massive destruction or devaluation of capital is previously verified to favor a strong and prolonged recovery (the Great Leveler).
- A perfected or mature technology that allows a sustained increase in productivity.
- A strong SIF that balances the distribution between labor and capital, and thus attenuates the extreme highs and lows of the economic cycle.



Table 3 World and Regional Indicators, 1820–2008 (Average Annual Composite Growth Rate in Percent)

<i>Gross Domestic Product</i>							
	1820–70	1870–1913	1913–50	1950–73	1973–92	1992–2008	1820–2008
Western Europe	1.7	2.1	1.4	4.7	2.2	1.9	<b>2.13</b>
Western Offshoots	4.3	3.9	2.8	4	2.4	3	<b>3.63</b>
Southern Europe	1	1.5	1.3	6.3	3.1	3.4	<b>2.23</b>
Eastern Europe	1.6	2.4	1.6	4.7	−0.4	2.6	<b>2.13</b>
Latin America	1.5	3.3	3.4	5.3	2.8	3.3	<b>3.11</b>
Asia	0.2	1.1	3	4.4	2.8	5.6	<b>2.12</b>
Africa	0.4	1.1	3	4.4	2.8	4	<b>2.16</b>
<b>World</b>	<b>1</b>	<b>2.1</b>	<b>1.9</b>	<b>4.9</b>	<b>3</b>	<b>3.8</b>	<b>2.31</b>
<i>Population</i>							
Western Europe	0.7	0.7	0.5	0.8	0.3	0.3	<b>0.57</b>
Western Offshoots	2.8	2.1	1.2	1.5	1	1	<b>1.87</b>
Southern Europe	0.3	0.4	0.9	1.4	1.4	0.9	<b>0.75</b>
Eastern Europe	0.9	1.3	0.4	1.2	0.7	−0.1	<b>0.79</b>
Latin America	1.3	1.8	1.9	2.7	2.3	1.4	<b>1.82</b>
Asia	0.1	0.6	0.9	2.1	1.9	1.2	<b>0.89</b>
Africa	0.3	0.7	1.9	2.4	2.9	2.2	<b>1.38</b>
<b>World</b>	<b>0.3</b>	<b>0.8</b>	<b>0.9</b>	<b>1.9</b>	<b>1.8</b>	<b>1.3</b>	<b>0.99</b>
<i>GDP per capita</i>							
Western Europe	0.1	1.3	0.9	3.9	1.8	1.7	<b>1.55</b>
Western Offshoots	1.4	1.8	1.6	2.4	1.4	1.9	<b>1.73</b>
Southern Europe	0.6	1.1	0.4	4.9	1.7	1.8	<b>1.35</b>
Eastern Europe	0.7	1	1.2	3.5	−1.1	3.2	<b>1.33</b>
Latin America	0.2	1.5	1.5	2.5	0.5	1.9	<b>1.27</b>
Asia	0.1	0.6	0.1	3.8	3.2	4.2	<b>1.22</b>
Africa	0.1	0.4	1	2	−0.1	2.2	<b>0.77</b>
<b>World</b>	<b>0.6</b>	<b>1.3</b>	<b>0.9</b>	<b>2.9</b>	<b>1.2</b>	<b>2.5</b>	<b>1.30</b>

Source: Adapted from Maddison (1995, 87) with data from Maddison Project (2019).

Significantly, only the first of these conditions has been present in the long upswings of the  $V$ - $Kv$ . The *catch-up* began in the 1970s in north-east Asia, specifically in South Korea and Taiwan, but the weight of these countries in the world total is limited, so it practically did not affect the world average. With the acceleration of growth in China since the early 1990s there is an effect on world averages. Without China, the average global growth would have dropped to 1.1–1.2%. However, we should not lose sight of the fact that the *catch-up* of the Asian giant has not reached the level achieved by Western European countries towards the 1970.<sup>5</sup> The closing of the gap between China and the US will depend, as Kai-Fu Lee (2018) puts it, of the race for the development of AI, which could turn China is not only a dynamic competitor, but a contender for world leader.

The remaining factors are basically absent. The relatively limited depth of the world crisis in the 1970s suggests that the massive destruction/devaluation of capital was far from that which resulted from the depression of the 1930s and Second World War; the years of 1970–1980 were basically re-engineering of power, in two main senses: (a) dismantling the welfare state and therefore nullifying the current limits to capitalist appropriation, and (b) subjecting the less developed countries to a regime of low growth through the neoliberal reform: Washington Consensus and the measures applied by the WTO (Sheppard 2016; Freeman 2019).

In relation to technology and its industrial applications, the period after 1970 has characteristics that radically differentiate it from the Golden Age. The accumulation of useful knowledge in both dimensions, propositional and prescriptive, has expanded rapidly since the 1940s although the big impacts start basically from 1970 on; above all, the epistemological basis of prescriptive knowledge has been deepened. Technology and digital systems are the product of this transformation, but unlike electro-mechanical systems, they are as Arthur (2009) suggests, capable of prolonged evolution based on the recombination of their elements. This potential, contradictorily, can give rise to irregular, unstable or weak growth trajectories, because if the succession of recombinations is relatively rapid as at this stage, resources are susceptible to misassignment or outright waste, without a clear allocation of benefits and social costs. The foregoing, as we have insisted, favors the disruptive repercussions, granting a great advantage to the *first movers*.

There is another difference with the Golden Age. As explained in Rivera, Lujano and Garcia (2018), the  $IV$ - $Kv$  had a strong SIF, so it predetermined a subsequent weak SIF as a function of the radicality of the structural crisis between the two Kondratiev. Possibly it is easier to explain it, based on Scheidel (2017). Although that Scheidel (2017) does not use the SIF concept, he emphasizes the

leveling of the capital–labor distribution. The historical rule as Scheidel (2017) argues is that unless the leveling forces have acted, the distribution will be unbalanced. Scheidel (2017) points out that there were two leveling forces that acted in the first half of the twentieth century: the world wars and the economic depression. As a result of this the leveling effect did not last beyond the 1970s, so the next Kondratiev will tend to associate with a weak SIF (associate to a weak crisis), predominantly favorable to capital.

As it is known, the SIF neo-liberal that has modulated the deployment of the digital paradigm had its epicenter in the Anglo-Saxon countries and to the extent that the US maintains hegemony, it was able to impose globally a set of principles, norms and organizations that regulate world process and to that extent support neoliberal globalization. The alternative to the SIF neo-liberal could be the coordinate market economy associated to countries such as Germany, Sweden and Japan (Dicken 2015, 181). That variety of capitalism (see Hall and Soskice 2001) could put certain limits on national scale, it did not contain the wave of counter-reforms such as privatization and the cult of shareholder value. In all the countries of Europe and in Japan the principles of competition based on neoliberalism prevailed and labor unions subordinate themselves, tax system were reform and the state apparently abandoned functions (see Palley 2005; Dumas 2010). There are two points to be added: on the one hand, the state tended to abandon or minimize functions related to social welfare and not those of capital promotion as explain by Mazzucato (2013). On the other hand, the “nemesi” of neoliberalism can be found in the meritocratic system, which in turn is inspired by the principles of Japanese–German corporatism (Bell 2015). If the competition become confrontation, it is possible that the future will resemble the past.

As explained in section II, the SIF of the  $V-Kv$  is expressed at several levels. In addition to that which refers to taxes, there are rules on liquidity and bank deposits established in the Basel I and Basel II agreements that contributed to reducing the cost of credit for corporations; we also have the transfer of assets from the public to the private sector through privatization and the revaluation of stock titles through a policy of sustained stock market boom. The importance of the loss of relative autonomy of the state in favor of *big capital*, which entails the regulatory gaps, was also explained.

In reference to the recombination of digital technology it is necessary to take into account the level of complexity achieved by this system. As shown in Table 4, it is possible to identify 5 basic levels, all derived from inventions originated in the US, but which reach international diffusion, promoting catch-up in certain countries. The first level corresponds to microelectronics (semiconductors), the

Table 4 Levels of Complexity of Technology and Digital Systems

<i>Levels</i>	<i>Period</i>	<i>Supported followers</i>
1: Microelectronics-consumer electronics Personal computer CAD-CAM systems	1970s–1980s	Japan, then South Korea
2: Digitization and networks (Internet)	Since the early 1990s	South Korea and Taiwan
3: Wireless communication <i>Smart Phone</i>	Since the late 1990s	Europe, Japan South Korea
4: Digital economy based on ecosystems <i>Platforms</i>	2001 onwards	China
5: Artificial intelligence	2018 onwards	China (potentially)

Source: Gordon (2016), Cassidy (2002) and Lanier (2013).

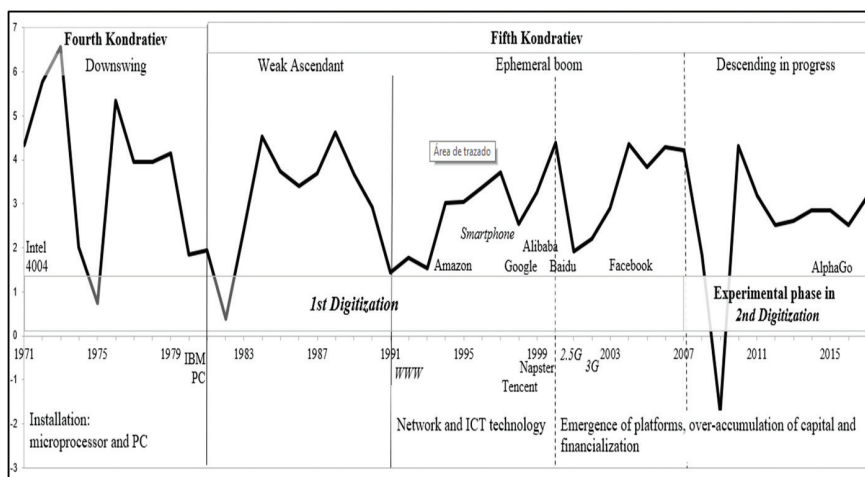


Figure 5 Annual Growth Rate of World GDP, 1971–2017 (%)

Source: <https://data.worldbank.org>.

birth of consumer electronics and the personal computer. As Dertouzos, Lester and Solow (1989) explain, Japan achieved a commercial advantage in DRAMs, and in consumer electronics, which served to consolidate its conversion into a technological power. Then in the 1990s, South Korea displaced Japan as a leader in DRAMs (Mathews and Sung Cho 2000). The other relevant process of diffusion

and catch-up is that which is verified in level 4, still in progress; and a fifth that involves a race between the US and China is about to take off (Lee 2018).

As previously explained, the install of computer/digital technological and the corresponding takeoff of the *III-IR* was verified with the conjunction between the microprocessor and the PC, that is, the beginning of the 1970s at the beginning of the 1980s. This stage is presided over, as is known, by the fracture of the capital–labor pact, justified by the neoliberal doctrine, breaking the previous equilibrium in the class distribution. As was emphasized, following mainly the scholars who study social inequality, the new conditions determined the relative increase of both the stock of capital, as well as the share of profits in national income. As we will see inequality has had consequences in the profile of the  $V-Kv$ .

Based on Figure 5, we will differentiate the sub-stages that are part of the  $V-Kv$  upswing, particularizing the most outstanding aspects of the role of technology and production systems. Each of these three sub-stages forms economic cycles of Juglar type, with crisis in the years of 1991, 2000 and 2008, which reveal the instability that characterizes this phase. The role of technology is revealed from the first cycle as we will see.

Between 1982 and 1991 the first display of digitization took place, presided over by the PC, axis of the computerized design and production system (CAD-CAM). We will talk about the stage of the standalone computer in these years, since the interconnectivity is only reached with the web browser or search engines, starting in 1991 with the installation of the first server, the Stanford Linear Accelerator System, which is equivalent to the launch of the World Wide Web (Gordon 2016). Before the search engine, towards the end of the 1980s, there was an e-mail with access to the Internet through dial-up telephone lines via providers such as aol.com (Gordon 2016); the quality of this first connection was slow and limited.

Automation through the CAD-CAM systems spread quickly thanks to a spectacular drop in prices and increased computer performance. Nordhaus (2007) estimates that since 1980 the prices (adjusted for performance) of the computer fell by 64% annually (Gordon 2016). This collapse increased business profitability to the extent that it cheapened computerized capital goods, determining that companies could maintain production levels or even raise them with lower capital expenditure (see McKinsey Global Institute 2010). We are talking about the beginning of a premature plethora of capital that characterizes the  $V-Kv$ . This surplus of capital at the global level is probably the main cause of cyclical instability (see Dumas 2010). This factor persisted, magnified by the concessions to which we have already referred (low tax rates, interest rates, privatization, share revaluation, etc.).

The true rebound of the *V-Kv* began around 1991–1992, the second sub-cycle. As Gordon (2016) says, this is the internet revolution, with rapid development of the search engines that led to the dominance of Microsoft with the Explorer based on the operating system Window 95. It should not be forgotten, as Gordon points out, that by the middle of the 1990, the Internet was slow compared to today. But from 1995 access to the internet grew rapidly. What derives from the above is human or social interconnectivity, whether for personal or commercial purposes. The so-called New Economy is an attempt to monetize social interconnectivity, something far from the dream of Berners-Lee, the inventor of the World Wide Web.

The term “new economy” is due to Brian Arthur (see Cassidy 2002). The conception was that thanks to technology growth would be constant, with full employment, but above all the overcoming of the economic cycle. The companies that interconnect with their customers through the Internet, called “dot.com,” would achieve the reduction of prices, the increase in the options of the client and a concomitant favorable impact on trade and production. The interconnectivity was accelerated thanks to the replacement of copper fiber by optical fiber.

The breakup of ATT in smaller regional companies meant the opening of a large space to invest, especially for innovations in telecommunications. *WordCom*, the telecommunications giant that for the most filled that space, is the emblematic example of what became the first financial bubble of the twenty-first century. The mania for technological actions, including “dot.com” and telecommunications companies, peaked around 1997. What triggered the panic in the stock market was the revelation of powerful accounting fraud in *WordCom*. The 2000 crash known as the Internet crisis closed this second cycle. The lasting legacy of the New Economy was *e-commerce* and Amazon as emblematic firm, plus a small group of “dot.com” that survived the crisis. The organizational form also emerged what would later know as digital platform, adopted by Amazon and the other companies.

The third cycle does not have the technological support of the previous one and carries the weight of a drop in productivity that has been interpreted as an economic devaluation of digitization (Gordon 2016); however, the processes that were previously set in motion persist and resume, despite the outbreak of the third crash (the real estate mania), the advance towards the second digitization. The digital economy is already under way and quickly reaches global breadth. For organizing digital resources in a competitive way the following supports are required: (a) cheaper hardware, more power and speed; (b) the development of mobile communications by means of multifunctional devices, which is achieved with the Apple iPhone OS model launched to the market in June 2007.

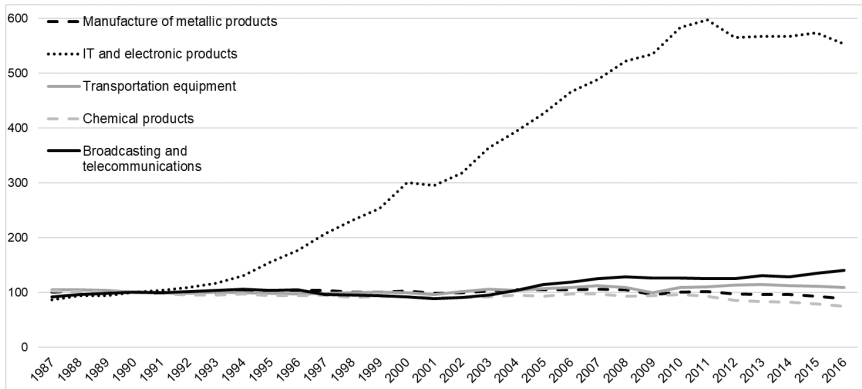


Figure 6 Multifactor Productivity in the United States, 1987–2016 (Base Index Numbers, 1990 = 100)

Source: [www.bea.gov/data](http://www.bea.gov/data).

The new economy can be conceived as a gigantic ecosystem, the largest of which is in China and is close to the 900 million users interconnected by means of powerful and cheap mobile devices (McKinsey Global Institute 2017a). This ecosystem also includes other companies, which compete and collaborate, integrated into platforms. In the US, the constitution of the digital economy has become a disruptive process, in which a handful of companies have taken control and establish high barriers to entry. As a result, the adoption of digitization among the US small and medium-sized companies is slow and limited; the McKinsey Global Institute (2017b) estimated that by 2016, only 30% of those companies had adopted digitization.

Regarding the performance of aggregate productivity, as noted, its rate drops substantially from 2004. However, this figure should be taken with reservation because it hides strong differences between what we can call the pre-digital economy (or poorly digitized) and highly digitized sectors. This difference is seen in Figure 6.

Figure 6 expresses one more dimension of the digital disruption to which must be added the already exorbitant concentration of global corporate profits. In summary, the profile of the  $V$ - $K$  $v$  and the relationship established between technology and production systems can be summarized in the following points:

1. Automation through the CAD-CAM system drastically reduced capital goods and increased their efficiency, but instead of being translated into an increase in gross fixed capital investment, this decreased in relative

terms; the profitability of large corporations soared, while their availability of additional funds to distribute among shareholders and investments instruments increased considerably.

2. In developed countries, salary levels in general are stagnated and labor conditions deteriorated. Wages in the majority of backward countries are low, but with an alternative to sub employment.
3. The government channels massive support to corporations and grants them self-regulation status.
4. The global digital economy is under the control of a handful of giants that controls the passage to A.I. or second level of digitization.

## Conclusions

In the  $V$ - $Kv$  upswings, the GDP *per capita* rate growth tends to adjust to the historical rate established since 1860. But this return to normality conceals the turbulence of this long wave that is derived from the combination of several factors. We want to stress the capital/labor pact break up that ameliorate the fall of the average return of capital; in spite on that, the exponential declines of computer equipment price, massively liberated capital, which fed successive speculative manias and led global capitalism to an economic depression attenuated by the lender of *last resort*. In this last sense, digitization feeds the capital glut.

Concerning the complex relationship between technological advances and industrial applications we stress that long periods of gestation are required, in which social experimentation leads to conflicts, so that industrial revolutions are processes that can span up to a century. Between the installation of ICTs in 1971–1982 and the crisis of 2008, almost 40 years elapsed. But to that period, it would be necessary to add the 1950s and the 1960s in which the deployment of microelectronics and the first era of the computer, the mainframe, is verified. The rupture of the capital/labor pact supported by the welfare state could have triggered the class struggle, but the formation of a global reserve industrial army has countered this possible reaction. Moreover, competition among workers in industrialized countries and those with lower wages sponsored social reactionism, especially xenophobia. The end of the cold war and the unification of the world market after the fall of the socialist world fed the idea of a world without borders.

The cycles that form part of the  $V$ - $Kv$  reflect this prolonged process of experimentation, which can be shortened to lengthen the Kondratiev or unify two waves around the same industrial revolution, which seems to be the case today. There are several processes that are still indeterminate. One of them is the speed with which the inventions related to the second digitization will become commercial veins and



may terminate the downswings, that is, sucking a good part of the surplus capital. Another, perhaps the most important, is whether capitalism as we know it will survive this systemic transformation as there will inevitably be repercussions on class relations and the structure of world power.

## Notes

1. From the mid-twentieth century the state in the US consolidated the relative autonomy it had begun to exercise with the anti-trust actions of the beginning of that century. After the “great leveling” that produced the depression of the thirties and the Second World War (see Scheidel 2017), the SIF was amplified to cover a more ambitious goal: the inter-class pacification by means of a certain balance in the distribution between capital and labor. It is attributed to the welfare state, the institutional axis of class pacification, having contributed to a more stable and sustained economic growth (see Marglin and Schor 1990), although with the prolonged deceleration of productivity and profitability at the end of the year 1960 onwards, that virtuous effect was diluted (Marglin and Schor 1990). The lesson of history is that distributional imbalance tends to generate long-term instability (mainly unstable growth). We will return to this point when characterizing the SIF of the digital era.
2. For Boyer (1988), the “mode of regulation” is constituted by institutional forms referring to the monetary credit, the workers’ standard of living, the type of competition and the state intervention modality.
3. In several categories of medicines, such as those for rare diseases developed by the US National Institutes of Health, they are ceded to the company that sets stratospheric prices and the government renounces legislation that allows set reasonable prices (Mazucatto 2013, ch. 9)
4. In general, the answer lies in the mark-up of costs derived mainly from offshoring (or extension of global value chains to low-wage countries); the oligopolistic company has the capacity to lower the cost to a lesser extent than the competitors, so that, even if the price falls, a differential is maintained that explains the extraordinary profitability of global corporations. On the mark-up of costs see Milberg and Winkler (2013, ch. 4).
5. For the period that extended from 1970–1980s, France, Germany and Belgium had on average reached between 85–98% of US productivity, which is equivalent to complete catch up (data from Maddison 1995).

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