Long waves, paradigm shifts, and income distribution, 1929–2010 and afterwards

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Abstract

The way income is distributed in an economy is perhaps the most notable result of its growth patterns. Understanding the joint persistence of economic crises and changes in social inequality since 1929 is considered a great challenge. This paper tries to analyze growth and income distribution in the long run using the concept of long waves, the evolutionary concept of 'systems', and empirical information. We conjecture that the social system is in turn an outcome of the co-evolution of four partially autonomous subdomains: (i) technology, characterized by a paradigm whose evolution follows the shape of a 'Schumpeterian boom'; (ii) the economy or productive system, essentially defined as the succession of intermediate-length fluctuations in investments, and strongly associated to sectoral and structural changes; (iii) science, which contributes to development by generating innovations; and (iv) institutions, which set the rules in which income distribution is framed. Following this scheme, the data reveal that income distribution is an emerging result from this 'global social system' and not only the result of economic productivity and technology; apparently, the weight in the income distribution of institutional factors is as relevant as economic and technological factors. Second, the long-run growth trends are most possibly non-linear and, to great extent, non-deterministic, which would support the representation of long-run phenomena as long waves. Finally, we have found that in the long period 1929–2010 and afterwards, two sub-periods are manifested, with very different regimes of income distribution: (1) 1929–1975, when inequality decreased, and (2) from 1975 to present time, when inequality increased. Concerning the years after 2010, two alternatives follow: either these correspond to the recovery phase of a new long wave, or to the end of the depression phase of our second period. In both cases, we are currently moving towards the expansionary phase of a new long wave, which will have important implications for contemporary economic policies.

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1 Introduction

The notion of evolution is unavoidably linked to economic growth. The evolution of socioeconomic systems, and the changes to which these are subject, are also related to economic crises, which seem to appear recurrently (Nelson and Winter 1982). In the last century, three major structural crises stand out in the global economy: the 1929 crash, the 1973 oil crisis, and the 2008 crisis. Clearly, if well-defined relations could be established between these structural breaks and the evolutionary changes that have taken place along this period, the mechanisms of economic growth and income distribution could be better understood. To fully unveil these mechanisms is important, as many neoclassical economists defend that crises are agents' forecasting errors, barely predictable, and that scientific knowledge would suppress them in time (Bernanke 2004; Clark 2009; Stock and Watson 2003).

Next to the role of economic crises and the structural changes that these might bring about, a key element in understanding the socioeconomic processes of evolution and growth is the way that income is distributed among economic agents. Distribution appears, after decisions on production, as the most evident social result. In this regard, inequality, particularly in less developed countries, stands as one of the primary socioeconomic issues the world has grappled with in recent decades and remains a significant challenge for the future (Caiani et al. 2019; Cynamon and Fazzari 2016; Decancq et al. 2009; Ostry et al. 2014; Tridico 2018). This challenge was already foretold by Sen (1995), who was a pioneer on denouncing inequality as a malady of contemporary societies.

This being said, what is the link between growth and social inequality? This is indeed a controverted question, which has remained open for a long time (Kuznets 1955; Škare and Druzeta 2016). Namely, Deaton (2013) claims that inequality might be a direct consequence of progress. However, the historical results yielded by different regimes of distribution might prove otherwise. In fact, Piketty (2014, 2020) identified a clear change in the trends of income distribution during the past century: intra-country inequality decreased after the Great Depression, especially after WWII, while it started to increase after the oil crisis of the mid-1970s. Curiously enough, this happened despite the fact that both periods were globally characterized by productivity improvements and strong economic growth. This brings to the fore several questions: has the economic evolution since 1929 been formed of two long waves? Has inequality increased in the past few decades and, if so, how this is connected to the aforementioned evolution? Which evolutionary factors have influenced the changes in income distribution, and how are these connected to those long waves?

Concerning long waves, the questions as to their definition will be progressively answered throughout the remainder of the Introduction. However, before entering this, perhaps the question that is most urgent and up for debate is: do long waves exist? Kondratieff (1935) was a pioneer in trying to answer this question, identifying three waves since the 18th century up until the first third of the 20th century. Then

came Schumpeter (1939), who completed Kondratieff's analysis with the inclusion of subjacent Juglar cycles and the endogenous explanation of these phenomena by means of his theory of 'creative destruction'. Then, for most of the century, these contributions were more or less ignored, up until the revival of the debate during the 1980s and 1990s. The enrichment of this field is patent in the collection of essays by Freeman (1996), which was one of the most prominent figures in the development of long waves theory, due to, among many other things, his well-known periodization and definition of the fourth and fifth Kondratieff waves covering the whole 20th century, as well as the characterization of their paradigmatic changes. Right now, the debate about the existence is far to be reached, as contemporary research is still dealing with these questions (Gallegati 2019; Korotayev and Tsirel 2010). Thus, we hope to contribute to this debate by: (1) connecting the long wave theory to social outcomes, or specifically, income distribution and intra-country inequality; and (2) extending the debate to our days as much as possible.

In this paper, we analyze the economic evolution from 1929 to 2010 (extending to the present as far as data allow), to reach a better understanding of the linkages between distribution and growth patterns in this period. For achieving this, we use the concept of long waves, supported in an evolutionary vision of the economy, and empirical information. We hypothesize, taking inspiration in Christopher Freeman's long wave theory[1] (C. Freeman 2008; C. Freeman and Louça 2001; C. Freeman and Soete 1997) and Bunge's concept of 'systems' (Bunge 1997), that the 'global social system' is, in the medium and long term, a superstructure formed of four co-evolutionary, partially autonomous, and subjacent sub-domains: (i) technology, which is characterized by a paradigm that follows the shape of a 'Schumpeterian boom'; (ii) the economic or productive system, essentially defined as the succession of intermediate-length fluctuations in investments, and strongly associated to structural and sectoral changes; (iii) science, which contributes to economic development by generating innovations; and (iv) institutions, which set the rules in which income distribution is framed. Each one of these domains presents its own characteristics. This would imply that income distribution should not be studied as a mere economic phenomenon, say, solely explained by a given technological level and marginal productivities, but as an emerging result of the 'social system'. Furthermore, the interactions of the various mechanisms crystalize in complex emergent economic evolutions, which we should expect to be non-linear and, to great extent, non-deterministic.

Now, we move on to explain our analytical schedule in more detail. First, concerning technology, we essentially follow the concepts of key innovations and technological booms as depicted by Schumpeter (1939), which have been developed in depth in further research, such as in C. Freeman (1996), Gutiérrez-Barbarrusa (2019), Louça (2021), and Silverberg and Verspagen (1995). Broadly

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[1] In this line, the synthetic vision contained in Giovanni Dosi's foreword to Freeman (2008) is key. Freeman considers the following co-evolutionary sub-systems: technology, the economy, science, policy, and culture. Although our scheme is not identical, we believe that it is fully coherent with Freeman's, as policy and culture can be thought of components of what we call the institutional sub-domain.

speaking, each long wave is characterized by a series of pervasive technological changes that are identified in the literature as changes in the 'techno-economic paradigm' (Dosi 1982; C. Freeman 2008; Perez 1983). These technological dynamics follow a life cycle, up until an exhaustion point is reached, thereby following an 's-shaped' evolution. Then, a new cluster of this type of innovation will appear, generating a structural crisis, and boosting a new long growth cycle. Translating this into our theoretical and empirical analyses, our conjecture is that there might have been two or three waves since the 1929 crisis, characterized by distinctive changes in the 'techno-economic paradigm' and, then, presenting different institutional frameworks (Perez 1989). The distinctive features of each wave could account for the different income distribution trends seen in two sub-periods: 1929–1975, when inequality decreased; and 1975–2010, when inequality increased. As will be seen later, this trend of increasing inequality seems to be extending into the period that came after the Great Recession. In short, this paper aims to describe each waves' own set of paradigmatic characteristics, explaining the aforementioned distribution trends, as well as the character of the changes experienced from 2010 onwards.

We are fully aware that the periodization of our long waves scheme might be *sui generis* in comparison to other analysis that are fully stablished in the literature, as we hypothesize that long waves start in the recovery phase, previous to expansionary phases. We can basically justify our choice for two reasons: on the one hand, we aim to capture changes in the techno-economic paradigm since the very moment of their inception, rather than when the new set of technologies is fully operational, which would ultimately correspond to the moment when the expansionary boost takes place; on the other hand, the start of the recovery phase is easier to locate, as it corresponds to the lowest point of the upturn, and is generally preceded by a deep and noticeable structural crisis. Meanwhile, in our opinion, Freeman (2008) locates the starting point of the long waves respectively around the end of WWII and the initial years of the 1980s, corresponding this to the origins of the expansionary phase. However, except for this difference, we think that our scheme is essentially coherent and complementary to Freeman's theory, and so would justify that our structural breaks are fixed around 1931, 1975, and 2010, as these years are usually identified as long waves' troughs in several articles (see the survey conducted in Gallegati (2019), as well as moments of high volatility and noticeable structural changes (Grübler and Nowotny 1990). This is but a methodological choice, whose justification is expected to be strengthened in our later analysis of the paradigm changes from one wave to another.

Returning to the description of our scheme, the technological characterization of long-run fluctuations, again following Schumpeter (1939), would also imply that there exists an underlying structure of intermediate-length fluctuations, of around 7–11 years (Fatás-Villafranca et al. 2012; Juglar 1862), which are thought to be related to fluctuations in investment. These shorter cycles will be important, and their identification should be supported by empirical data. Furthermore, it should be underlined that changes in the sectoral structure of the economy play an important role in these medium-term fluctuations. Changes in the techno-economic paradigm

that bring about a new long wave usually affect productive sectors in different ways, which also determine new investment and capital formation patterns. These adjustments in investments are important factors behind the configuration of Juglar cycles (Pasinetti 1981, 1993).

Nonetheless, the technological and economic characterization of the social system is, by itself, insufficient to understand the mechanisms of long-run income distribution trends (Kuznets 1940; Harcourt 1969). Our results support the hypothesis that the weight of institutional factors on income distribution is as relevant as economic and technological factors. Furthermore, the cumulative changes in institutions might be explained by ideas and beliefs, and so by the dominant scientific component (North 2005). In our specific case, the specific state of knowledge in economics is strongly relevant.

To carry out this analysis, the paper is going to follow this structure: in Section 2, data and methodology are presented. In Section 3, we will focus on the cyclical components of the economic system. We will check the possible division of the period 1929–2010 in two long waves (as well as the possibility of a third wave starting after 2010), and their specific inner structures concerning the intermediate length fluctuations that make up each one of them. These will be identified by applying band-pass filters to the data series. In Section 4, we address the remainder of the components that form the social system, that is, science and institutions. We will describe their characteristics during each period, and their changes, trying to strengthen our hypothesis of the existence of different long waves. In Section 5, we will link the social system's mechanisms or components of each wave to the different income distribution regimes that can be identified in these two periods, showing their role on the evolution of social inequality. Finally, in Section 6, some conclusions are drawn.

2 Data and methodology

2.1 Data

To contrast the conjectures and questions we are positing will be a fundamental element of our analysis. We are using the following quarterly data series for the empirical identification in Section 3: output growth rates, gross investment growth rates, and industrial production indexes. Our sample includes the United States, Germany, France, Italy, Spain, the United Kingdom, and Japan, as we believe that these can provide a good representation of developed countries. American quarterly time series for the whole period are extracted from the FRED database (2023a, 2023b, 2023c). For the rest of the countries, data were extracted from Maddison (Bolt et al. 2018) and the OECD (2023). Finally, we also use price series as a support in the descriptive analysis in Section 3.2 (OECD 2020a), as there is evidence of long wave patterns also existing in prices (van Ewijk 1982). Finally, descriptive data about inequality is extracted from World Inequality Lab (2022).

2.2 Methodology

As we have commented previously, we follow Schumpeter (1939) in some of his basic assumptions (technology booms and investment cycles) when treating long- and medium-term fluctuations, while being aware of the different sectoral, institutional, and social characters that the latter fluctuations may present in each long wave. Specifically, we accept the existence of four-phase cycles (recovery, expansion, recession, and depression) in each long wave, assuming for clarity that these phases start at the trough or lowest point of the upturn phase. As a consequence, the first phase in our long waves is that of recovery, the period of low growth in which new technologies start to incorporate into the techno-economic paradigm. Additionally, given empirical results and Schumpeter's suggestion of interpreting data without dogmatism, we do not necessarily assume his hypotheses concerning the wave-length, of around 50 to 60 years, the number of Juglar cycles (six in each wave), or the non-relevance of events like wars or social conflicts. With the data available, we are going to check if the period 1931–2010[2] can be divided into two waves, and extending the analysis beyond 2010 as much as possible, to check if there are indications of a third wave starting around then. Thus, we split this period into three sub-periods, according to different characters in the income distribution regimes: (i) 1931–1975, with decreases in inequality; (ii) 1975–2010, when inequality increased; and (iii) from 2010 onwards, with initial signs of a further intensification of inequality. The existence and time delimitation of these waves are supported by evidence from previous literature (Bieshaar and Kleinknecht 1984; Grübler and Nowotny 1990; Metz 1992). Jarne et al. (2007) also support the existence of a technological boom after 1975. Furthermore, applying a Chow (1960) test to available data for 1929–2022, we will see signs of strong structural breaks in the production series of our sample around 1931, 1975, and 2010, supporting our hypotheses of two long waves, and the possible start of the recovery phase of a third one.

Although this has already been previously addressed, a quick clarifying note about our choice of locating the break around 1975 must follow. We believe that, around 1975, there were institutional, scientific, and social changes noticeable enough to at least consider that this corresponds to a point of structural change (and thus, of paradigmatic social and technological changes). Namely, the suspension of the gold standard towards the end of 1971, and the new wave of globalization favored by the soaring in oil prices and the birth of petrodollars, were huge changes in the global monetary system that took place then. Additionally, from a technological standpoint, ICTs, the leading innovation of the second wave, started to consolidate in the techno-economic paradigm in the 1970s, while 1980s is the decade in which their consumption started to spread to the masses. Finally, all these new situations were also favored by an institutional changing environment, biased towards

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[2] Note that this period differs slightly from what would be delimited by the two crises, 1929 and 2008. According to data, the recovery from the 1929 crisis would start around 1931, while the lowest point of the downturn after the 2008 crisis would be located around 2010.

liberalization and the repeal of several regulations imposed in the previous period. All these changes will be treated in more depth in Section 4.

Furthermore, according to our empirical results, as we are working on a period of around 90 years in total, the lengths of our long waves are going to be shorter than those defined by Kondratieff (1935) and assumed by Schumpeter, of around 50 to 60 years, and longer than Kuznets cycles of around 20 years (Solomou 1988). This is coherent with our conjecture regarding the non-deterministic character of long waves, being rather evolutionary processes. Furthermore, we should not exclude the possibility of advances in scientific knowledge in economics and innovation being able to explain the reduction in the length of long-term fluctuations to some extent.

In addition, we hypothesize, following Schumpeter (1939), that long waves also present an inner structure of intermediate length fluctuations (7–11 years), commonly known as Juglar cycles, which are strongly linked to investments in incremental innovations in new leading sectors. This hypothesis of shorter cycles nestled under long waves has already been treated in the literature (Berry et al. 1993). We check for their existence by applying Baxter-King (1999) filters to our data series. As has already been commented, the number of subjacent cycles contained in a wave are not necessarily six, as Schumpeter claimed.

After conducting a short empirical analysis and confirming the existence of subjacent cycles in our hypothesized long waves, we will move on to the study of changes in the productive, scientific, and institutional components of the paradigm. This will constitute a complementary proof of paradigm shifts taking place around the mid-1970s and the early 2010s. In this review, we will bear in mind the existence of social episodes such as WWII, Vietnam, May of 68, or even the current conflict in Ukraine. This differs from Schumpeter's vision in the sense that wars and serious social conflicts cannot be separated from evolutionary processes. Namely, it is difficult to conceive the inception of the welfare state without the development of WWII, or to ignore the influence of the French May in the formation of contemporary European societies, or even the foreseeable consequences of the situation in Ukraine on economic restructuring during the upcoming years.

3 The cyclical dynamics of the economic system from 1929 to 2010

3.1 Structural change between long waves

As has already been pointed out, we posit two conjectures about the cyclical dynamics of the economic system since 1929: (i) there exist two long waves, each associated to different technological booms, and (ii) these structures are associated to a series of subjacent intermediate-length cycles. Although the existence of these two long waves is going to be gradually unveiled in the following sections, an initial approach is developed by applying Chow tests to production series, showing signs of a strong structural break around 1975 in the countries of our sample. Results are shown in Table 1 below, showing that 1931, 1975, and 2010 are significative upturns. To confirm the robustness of these results, additional tests were carried out

Table 1 Chow test for checking structural breaks in the production series	Country	Year	*F*-distribution value	*p* value (α = 0.05)
	USA	1931	193.7760	0.0000
		1975	80.7665	0.0000
		2010	3.0035	0.0308
	UK	1975	12.4920	0.0000
		2010	3.2871	0.0214
	Spain	1975	7.9202	0.0000
		2010	2.7394	0.0444
	Japan	1975	11.3983	0.0000
		2010	5.9711	0.0006
	Germany	1975	7.5644	0.0001
		2008 (*)	3.0698	0.0286
	Italy	1975	24.9456	0.0000
		2010	4.7909	0.0029
	France	1975	75.3313	0.0000
		2010	4.5702	0.0039

At a significance level α = 0.05, the null hypothesis that there is no structural break is rejected when *p* value < α.

(*) *Nota bene*: For Germany in 2010, the null hypothesis cannot be rejected. Nonetheless, the results are favorable for 2008, and so are presented in this table.

Source: own work.

for other key years, such as 1968 and 1983, not being possible to confirm generalized structural breaks in neither of them.

Table 1 reveals that the structural break that splits the whole period takes place in 1975 for the seven countries of our sample, which are very representative cases of the global economy. Then, we can rationally assume that 1975 is a turning point for a new long wave, following the previous one which started in the 1930s.

This break that takes place in the mid-1970s, as was previously commented, is associated with the 1973 oil crisis, but also to the technological boom linked to the development of computers and ICTs. The assumption of oil being a limited resource, the increasing negative impacts on the environment, the computing technological boom, and the increasing globalization and market liberalization are clear symptoms of a paradigm shift. Finally, in the years 1931 and 2010, the other two upturns, were chosen in compliance with our criterion for choosing the starting points of the long waves.

3.2 Sigmoid evolution of the waves

Before dealing with the subjacent cyclical structure of long waves, some characteristics about the shape and profile of the evolution of Kondratieff cycles must be clarified. It is generally assumed that Schumpeterian technological booms

follow the evolution of a Gompertz sigmoid curve. That is to say, technological evolutions can be represented as 's-shaped' curves, with a leap when radical innovations are introduced, fostering sustained growth up until a phase of exhaustion is reached and a crisis ensues; then, the established innovations will be substituted by the leading technologies of the following paradigm. Another feature that can be expected of these growth processes is that expansionary phases are associated with higher volatility; in contraposition, when the technological paradigm starts to exhibit signs of exhaustion, rates of growth usually vary within narrower bands (see, for example, Jarne et al. (2007), which empirically confirms this kind of evolution during what we consider to be the second long wave, by using USA industrial capacity indexes). Thus, the volatility of growth rates should be illustrative enough to represent a determined location in the wave. See Figure A1 in the Annex, in which this phenomenon can be checked for USA growth rates during our whole period of study, and so, for our long waves.

Finally, these specific evolutions of long waves have also been formally characterized in theoretical models. Namely, Fatás-Villafranca et al. (2012) proved the sigmoid evolution of long waves, linked to processes of Schumpeterian booms and creative destruction, by taking into account capital stocks, and processes of technological obsolescence and exhaustion points.

3.3 Juglar cycles delimitation

Now, we address the of study the inner structure of these two waves, to complete the economic facets of the social system's evolution. Our aim is to prove the existence of intermediate length fluctuations which are related to investments and should last around 7–11 years, and to establish the number of these fluctuations in each long wave.

For the identification of these fluctuations, we are going to apply Baxter-King (1999) filters to several quarterly series in order to extract their intermediate-length cyclical components. We apply Baxter-King filter for two reasons: first, because we are interested in a global vision, and we intend to treat data for different countries in a similar way; second, because direct data, as in, namely, the NBER cycles delimitation, jointly capture long-, medium-, and short-length cycles, and we seek to erase the latter.

We also adapt this methodology according to the length of cycles we are seeking. Let $BK_k(p,q)$ denote the Baxter-King filter used to detect cycles of a minimum length of p quarters and a maximum length of q quarters. Meanwhile, k refers to the lag at which the filter's weights are truncated at both tails, when applying a finite moving average. For obtaining cycles ranging from 7 to 11 years, we fix $p = 28$, $q = 44$, and $k = 24$ (it is already proved that the filter yields optimal results for $k \geq 12$, see Baxter & King (1999). Note that this technique tends to show the deviations from the mean growth of the period, removing the short-length cycles. As we have explained above, Juglar cycles are related to productive causes – and, specifically,
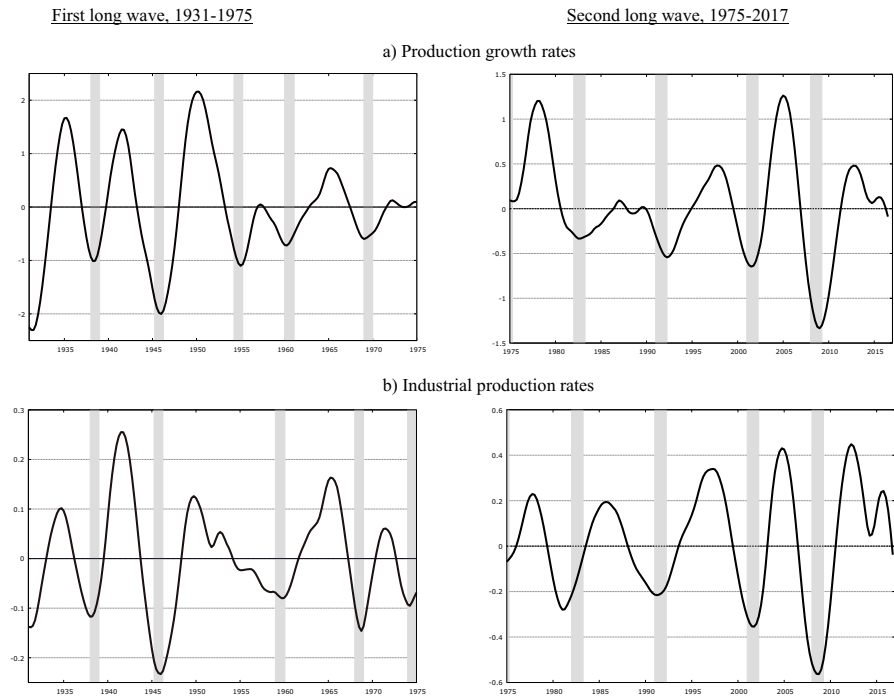
First long wave, 1931-1975   Second long wave, 1975-2017

a) Production growth rates

b) Industrial production rates

Fig. 1 Filtered growth rates for the United States. Source: own work based on Federal Reserve Economic Data (2023a, 2023c)

to investment fluctuations –, so we focus on studying the following series: gross national product growth rates, industrial production indexes, and gross investment growth rates.[3]

Figure 1 shows the results of applying the Baxter-King band-pass filter to the United States times series.[4] The left column shows the evolution for the first long wave, while the right column refers to the second long wave. Looking at the first wave figures, the valleys show that both series coincide in that it might be formed of five different subjacent cycles. Concerning the second long wave, it seems to be composed by four subjacent cycles.

As the isolated case of the United States could be not representative enough as a case of a global long wave, the filter is applied to other developed countries: the United Kingdom, Spain, Japan, Germany, Italy, and France.[5] Figure 2 shows the output growth rates results for our first period, while Figs. 3 and 4 respectively show the results for the output growth rates and industrial production indexes during the second wave.

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[3] Supplementary information about data series, including prices, is available upon reasonable request.

[4] Results for the series of gross investment growth can be consulted in the Annex (Figures A2 and A6).

[5] Results for Italy and France can be consulted in the Annex (Figures A3–A6).
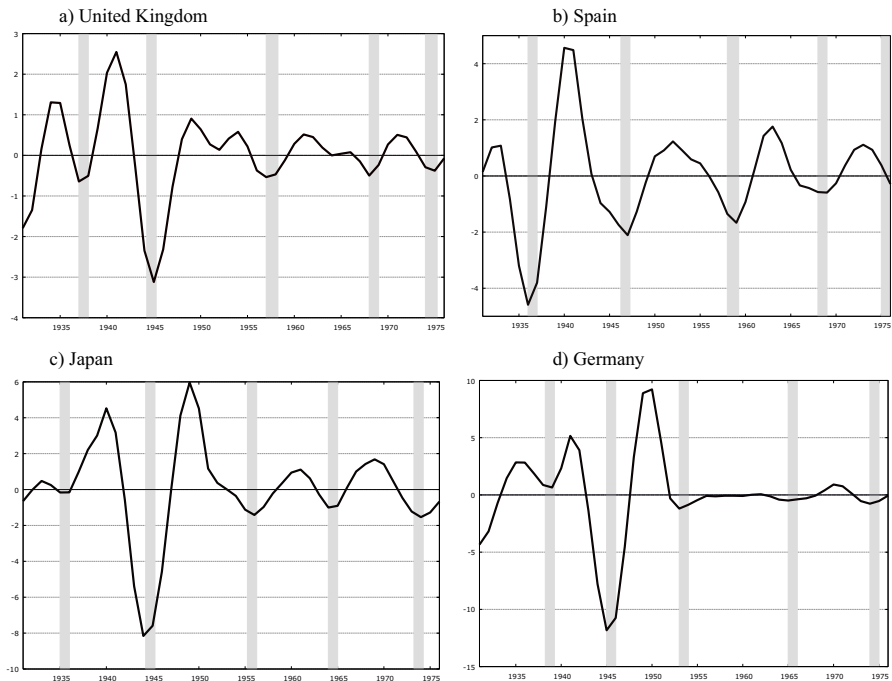
Fig. 2 Filtered output growth rates, first long wave. Source: own work based on Maddison Project Database 2018 Release (Bolt et al., 2018)

These results yield a similar evolutionary pattern to that obtained for the US. Five subjacent cycles can be identified in our first period, while four subjacent cycles can be detected in the second. The time delimitation of the cycles, which is also very similar to that observed in the American case, is shown in Table 2 below.

An interesting fact can be underlined: the case of Spain at the beginning of the second wave might appear to not follow the same pattern as the other countries. In fact, this period is clearly anomalous, as 1975 marked the start of a period of institutional adjustments to democracy. Hence, we can insist again in the fact that our scheme of cycles is not deterministic because the socio-institutional contexts matter and can influence the evolutionary trajectories that are imposed by technology.

For now, we have partially confirmed our conjecture about the existence of a first wave, going from the Great Depression to the oil crisis, which is composed of five cycles; and with a second wave that goes from the oil crisis to the Great Recession, and is formed of four cycles. As a final remark, following our scheme, a third wave could have started around 2010, with a first intermediate-length cycle ending around 2020 (coinciding with the current crisis derived from the COVID-19 pandemics), see Figs. 1, 3, and 4; however, this cycle could also correspond to the end of the depression phase of our second wave. Undoubtedly, this topic would require further research and is an open line for future research. This is especially important
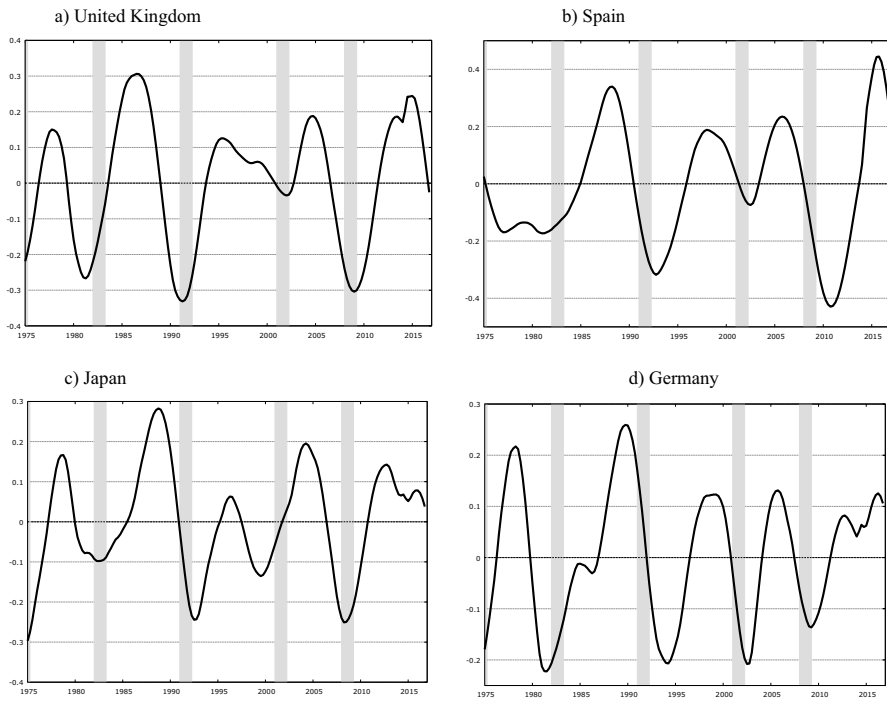
Fig. 3 Filtered growth rates, second long wave. Source: own work based on OECD (OECD, 2023) data

because, according to our results, in both cases, we are currently moving towards the expansionary phase of the new wave, which should have clear and positive consequences on future growth.

4 The 'wave paradigm' components and their changes through time

We hypothesize that each long wave has its own scientific and institutional mechanisms that, in conjunction with technological and economic sub-systems, determine the evolution of the social system. All of these 'sub-systems' are interrelated and form a paradigm, which could be defined as 'a privileged level of analysis of the interactions and co-evolutionary dynamics among [these four] sub-domains […]', as Freeman (2008) claims. In this section, we intend to describe some characteristics of the scientific and institutional sub-domains underlining the differences that arise from one wave to another.

4.1 Technological and scientific context

Following Kuhn (1962), science is structured around 'paradigms' that evolve and change through time in a succession of scientific revolutions and synthesis. '[The]
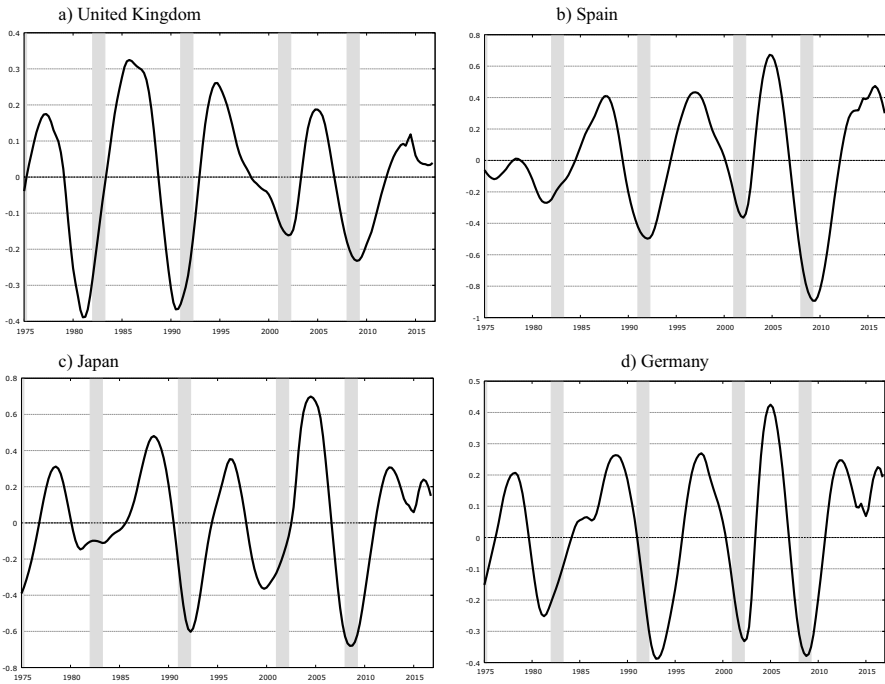
Fig. 4 Filtered industrial growth rates, second long wave. Source: own work based on OECD (OECD, 2023) data

Table 2 Structure and length of the long waves

Long wave	Approximate length	Juglar cycles	Approximate length	Long wave phase
c. 1931–1975	44	1931–1939	8	Upswing: recovery
		1939–1947	8	Upswing: expansion
		1947–1958	11	Downturn around 1954
		1958–1968	10	Downswing: recession
		1968–1975	7	Downswing: depression
c. 1975–2010	35	1975–1983	8	Upswing: recovery
		1983–1992	9	Upswing: expansion
		1992–2002	10	Downswing: recession
		2002–2010	8	Downswing: depression
c. 2010–?		2010–2020 (?)	10	Upswing: recovery

Source: own work.

transformations of these paradigms […] are scientific revolutions, and the successive transition from one paradigm to another via revolution is the usual developmental pattern of mature science' (ibid.: 12). Bearing this in mind, we move to the description of the two different scientific contexts that arose when each of the

waves described above started. We will specially focus on changes in productive technologies, as well as in changes in the mainstream vision of economics.

4.1.1 Productive technologies

An evolutionary conception of technical progress implies the assumption of a hard core of technologies that cluster in time and develop through a life cycle that ends in an exhaustion point; when this point is reached, this set of technologies would be progressively substituted by a new wave of innovations, forming a new technological paradigm (Dosi 1984; Mensch 1979).

During the first wave, 1931–1975, a key process innovation appeared: mass production, especially in durable consumption goods industries – automobiles, televisions, and domestic appliances. The availability of new products at low costs caused another change in demand patterns: namely, mass consumption. This was partly allowed by the expansionary fiscal policies that were applied for the promotion of economic recovery from the Great Depression and WWII. These favored low- and middle-income groups, which resulted in the consolidation of a consumerist middle class, with important implications towards achieving a progressively more egalitarian income distribution.

The purchase of these durable goods (especially automobiles) had a component of achieving a certain standard of living, and, although sometimes subjectively, allowing access to higher levels of income. In developed post-war societies, advertising played an important role in promoting this lifestyle – which was ultimately possible due to the spread of television, radio, and mass media in general. Nonetheless, mass consumption was not only present in durable consumption. Another important change took place in eating habits, thanks to the development of industrial livestock production, which cheapened the prices of meat. Another important change that contributed to rising life standards was the commercialization and diffusion of antibiotics. Medicine can also be considered to be shifting towards a more technological focus from this point onward.

The development of aeronautics was also a key feature of the period, as it served several purposes. On the one hand, airplanes enabled a more efficient way of transporting passengers and commodities. On the other hand, the aircraft industry played an important role in military R&D. In this respect, the space race that confronted the US and the USSR amid the Cold War was a key event. Thereafter, the aeronautic industry experienced important changes: the appearance of Airbus in 1970 broke the American monopoly and opened the industry to a higher level of competition, which is also characteristic of the following wave (Klepper 2002; Klepper and Simons 2005); bigger planes were being developed, which would result in the birth of low-cost aviation in the following decades; and, finally, rockets, satellites, and aerospace in general would gain importance.

Concerning energy, oil substituted electricity as the main productive input. Thermal and catalytic cracking processes made oil production easier. Also, the development of the automobile and aeronautic industries created a higher demand for oil as fuel for combustion engines, displacing coal. Related to this is the development of the petrochemical industry during the 1930s, and of organic chemistry and synthetic

materials, which were key inputs during this period. This being a paradigmatic feature of this wave, this is why it has been named the 'oil wave' (C. Freeman 2008). In short, the techno-economic paradigm that has been described above was notably different from the dominant technologies that were present from the last quarter of the 19th century to the Great Depression, which were mainly electricity, steel, and heavy engineering.

Now, we move on to establish the differences with the following wave's technological paradigm. This will allow us to properly talk about a new technological boom, and so a new long wave, which could be classified as the 'ICTs wave' (C. Freeman 2008), as it was mainly based on information and communications technology (ICTs). Concerning information, the main innovation was computers. Its intellectual base can be attributed to Turing's (1937), Max Newman's (1948), and von Neumann's (Goldstine and von Neumann 1948) contributions in their works with algorithms and computer design. The invention of integrated circuits in the 1950s, IBM's punched cards in the 1960s, and Intel's microprocessor in 1972, were all important milestones. Then, mass-production of computers was a key event, with the first personal computer being launched by Commodore in the late 1970s. Furthermore, in these years, we also find the antecedents of the Internet: the US Department of Defense developed the first interconnection web for federal computers, ARPANET, towards 1967. With respect to telecommunications, the key invention was the mobile phone. In 1973, Motorola developed the first completely portable telephone. Furthermore, the development of computers and telecommunications might indicate another change in consumption patterns, now mass consumption of cheap products, but more biased towards leisure-oriented purposes.

Concerning energy, the oil crisis made developed countries re-think their energy mix to reduce their dependence on crude oil. During this period, the initial development of renewable energy sources was important. Despite this, these sources have not reached their maturity phase, except for maybe wind energy. Energetic transition might not be complete yet but, in 2015, renewable sources were around a fifth of total energy in all the world, and 17% in the European Union (IRENA 2018). As for intermediate inputs, the use of plastics has been paradigmatic, being a strongly pervasive technological change. The development of the petrochemical industry during the previous wave and of chemical components like polymers took a big part on the proliferation of plastics, and its constitution as a fundamental input during this wave, especially contributing to shortening production times. This change in productive processes also favored the stagnation of wages, which was in turn compensated by the availability of cheap consumption goods (clothing, furniture, etc.), usually purchased by middle and low incomes. Furthermore, this was caused by institutional changes in the labor market rather than by decreases in labor productivity. It can then be inferred that this model of consumption was an important factor in the increases in inequality during this period.

As for health and nutrition, in medicine, the improvement of surgery and internal medicine was a characteristic feature of this period, heart surgery being a paradigmatic case. In addition, further improvements took place in relation to transplants and diagnosis; endoscopy and magnetic resonance imaging were first experimented during this phase and started to generalize towards the end of the century. The use of

laser technology in surgery can also be underlined, contributing to consolidating the increasing technological character of medicine. Lastly, during the 'Green Revolution' spanning from the 1960s to the 1980s, new technologies began to be applied in agriculture. This led to significant increases in productivity, subsequently reducing food costs and the cost of workers' subsistence (this probably favored an increase in relative inequality, even though low-income needs were covered to a higher extent). We refer to the use of new pesticides, fertilizers, and irrigation processes, and the even the polemic inclusion of genetically modified food. A remarkable fact was the introduction of new high-yielding varieties of rice and wheat in developing countries. Finally, from the perspective of income distribution, another fact stands out regarding health. We refer to the emergence of a private health system during this period, which can be seen as a counterpoint to the prominent role of public health in the context of the welfare state construction in the preceding wave. This is another type of differentiated consumption that can widen social inequality.

Considering the possibility of a new long wave starting around 2010, this would bring about a new technological change that should overcome the limitations of the 1975–2010 paradigm. In this sense, several advances can be underlined: the leap from microchips to nanochips and quantum technologies, further advances in energy related to the consolidation of renewable sources and nuclear fusion power, the application in medicine of discoveries in genetics and metabolic processes, or the possibility of a new space race with an important role of military technologies.

4.1.2 Economic science

Booms in productive technologies can be partially explicative to characterize our two waves, but it needs to be analyzed jointly with the scientific context. For the sake of simplicity, we are going to limit the exposition to the evolution of paradigms in economics, whose translation into productive systems could drive us to the same conclusions.

We consider the publication of Keynes' *General Theory of Employment, Interest and Money* (1936) as a milestone in economics during the period 1931–1975. This book was a reaction against the previous scientific paradigm, that is, the Marginalist Revolution and supply economics. Confronting Say's law, according to which economic crisis are always a result of insufficient production, Keynes identified the Great Depression as an under-consumption crisis, provoked by a decrease in investment and, consequently, in aggregate demand. Hence, an increase in public expenditure could increase demand and be a solution to the crisis. In addition to this theoretical framework, the success of Roosevelt's New Deal of 1933, a package of expansionary fiscal measures, contributed to the formation of a new academic vision with demand in the center of its analysis. Another example of expansionary fiscal policies during this period is the Marshall Plan, which was American funding for the reconstruction of the post-war Europe.

During the late 1930s and the 1940s, a scientific revolution took place in economics. Keynesian theories were adapted by neoclassical economists, which derived in the formation of a new paradigm: the 'neoclassical synthesis' (Roncaglia 2005). We find here, on the one hand, neoclassical microeconomics based on the marginalist

concept of utility and an atomistic view of individual rational optimization, where Arrow and Debreu (1954) general equilibrium model played an important role. On the other hand, we find Keynesian macroeconomics, that is to say, disequilibrium models for the explanation of short-term unemployment with the inclusion of price and wage rigidities. To this extent, Hicks' (1937) simplification of Keynes' scheme, the IS-LL simultaneous equilibrium model, constituted a pioneer work.

Moreover, in the theoretical apparatus of this period, the exogeneous growth models are of special importance. We specifically refer to Harrod–Domar (Domar 1946; Harrod 1939) and Solow–Swan (Solow 1956; Swan 1956) models, which reflected the scientific consensus of their time. Due to the influx of Keynesian ideas, these models incorporated the notions of savings and consumption to represent effective demand. The Schumpeterian framework also played a role, in the sense that an exogenous rate of innovation was considered as the generator of economic growth.

We cannot end this discussion without talking about the Phillips curve, which is important in the explanation of the exhaustion of the paradigm and its subsequent change. The Phillips curve was an instrument used during the synthesis years for predicting inflation. This model showed an inverse relationship between inflation and unemployment variation, with was invalidated with the coming of stagflation during the 1970s crisis. Indeed, stagflation created suspicion around the Keynesian-synthesis theories and as will be explained later, the monetarist revolution led by Friedman revealed to be an attractive academic *corpus* in the hands of neo-liberal politicians.

Here, we have seen a typical evolution of a Kuhnian scientific paradigm: first, we see a revolution, a synthesis, and the formation of a new paradigm; later, a new phase of intern coherence with the paradigm's basic axioms; then, the opposition from heterodox scientists arises, until a new revolution takes place, and a paradigm change is forced. This process constitutes the mechanism of scientific progress, as the succession of revolutions and synthesis contribute to fortify the hard core of scientific knowledge. Furthermore, we have seen the importance of the translation of these theoretical visions into policy measures, and so into the realm of physical production, which would help to characterize productive systems and the technologies that are being developed and applied there. In particular, the strong industrial and economic intervention of governments centered in sustaining low and middle incomes, bearing in mind that the consolidation of a consumerist middle class was important for recovering from the Great Depression. This was a key factor for reducing social inequalities and polarization.

In contrast to this, around the mid-1970s, the Monetarist critiques to the Phillips curve set the foundations for a scientific paradigm change (Friedman 1968; Phelps 1968). The setting of inflation objectives through monetary policy and interest-rate manipulation gained importance during the following decades. In turn, fiscal policy fell into second place, as public expenditure effects on aggregate demand were supposed to be anticipated by the rational economic agents, so, in the end, it would only contribute to generate inflation. Rational expectations (Muth 1961), thus, were revealed to be an important instrument for the monetarist critique of expansionary fiscal policies. Another characteristic of this paradigm is that of capital market efficiency (Malkiel and Fama 1970). According to this, perfect and complete

information prevails in financial markets, so the existence of speculation and bubbles would be denied. This theory would also be useful to justify financial deregulation and liberalization. Finally, public choice theories constitute another important feature of this paradigm (Buchanan and Tullock 1962), characterized by the Laffer curve, used for justifying tax cuts for higher incomes. All these factors contributed to increasing income concentration by promoting an individualist (utility/profit maximizing) thought, and specifically a loss of confidence in public entities, confronted to the extended feeling of social belonging of the previous period.

An essential contrast also appeared in relation to the representation of dynamic growth processes. Endogenous growth models, in the tradition of Ramsey (Cass 1965; Koopmans 1965) and Romer (1986), were now at the center of the analysis. These incorporated a Schumpeterian flavor, where the role of technological change, represented now by an endogenous parameter, was still important in promoting growth. Now, however, the Keynesian concept of demand vanished, highlighting the role of the entrepreneur in detriment of that of the public sector, which was reduced to a mere provider of human capital (Lucas 1988). Thus, the change of focus in the explanation of growth mechanisms seems to represent the scientific consensus of this period, that is, a shift towards a smaller role of governments in the economy, because these passed to be seen as a source of distortion from the efficiency displayed by markets.

In short, this intellectual corpus was attractive for neoliberal adepts, and was soon adapted into policy. During the second wave, the control of prices growth turned to be the main objective, by achieving a stable rate of inflation (Taylor 1993). These inflation-oriented monetary policies substituted the expansionary fiscal policies of the previous period. Besides this, neoliberal agenda also orientated towards the restoration of class power and the social structure that existed before WWII, which helped to revert the trends in income distribution, with inequality sharply increasing from the 1980s (Harvey 2005).

4.2 Institutional context

From an evolutionary perspective, we should also analyze the institutional characteristics of each wave and cumulative institutional change as a key feature of wave paradigms. According to North (2005), institutions are a reflection of society's ideas and beliefs, so the changes that take place in the scientific context might be directly related to institutional changes. We focus on three institutional aspects: (i) monetary and financial system; (ii) the role of government; and (iii) labor market.

In the first wave, concerning the monetary system, a new order was established at Bretton Woods in 1944, substituting the gold standard. This new system was based in the universal convertibility of currencies into dollars. It should be underlined that, although it is true that this important change in the monetary system takes place far ahead from the start of the wave, we believe that this was an unavoidable consequence of both the financial struggles of the 1930s and the problems of convertibility to gold derived from war payments after 1918, and the new world order that had to be set after WWII. This was also a period of financial regulation. The

Glass–Steagall Act of 1933 was approved to separate commercial banking from investment banking. The Bank Holding Act of 1956 regulated financial holdings' activities, preventing them from being integrated by different companies dedicated to commercial and investment activities at the same time, and reducing market power concentration.

On the contrary, the second wave brought about changes in a different direction, starting with the complete suspension of gold convertibility in 1971. Exchange rates started to float, and commodity money evolved into fiat money, which consisted mainly of bank money (favored by financial innovation: credit cards, ATMs, securities, etc.). With the rising importance of bank money, a demand for financial deregulation arose, because regulation was constraining its activities (Sherman 2009). In America, the Garn–St Germain Depository Institutions Act of 1982, which authorized the expansion of S&L activities, was a first step into breaking the separation between commercial and investment banking. With the Gramm–Leach–Bliley Act of 1999, the Glass–Steagall Act was repealed. Finally, the Commodity Futures Modernization Act of 2000 revoked regulation concerning financial derivatives. The 'rationale' behind this wave of deregulation was that ITCs would help to make risk monitoring easier and more efficient. Another justification for deregulation was the urge for globalization and the liberalization of capital markets.

Regarding the public sector, its expansion during the first of these waves constitutes an important institutional feature (Briggs 1961). Europe confronted postwar reconstruction around the figure of the welfare state, based on three pillars: (1) Unemployment, sickness, and disability insurance; (2) public pension funds for retired workers; and (3) benefits in kind mainly related to health and education. In short, the role of governments increased during this period, shaped either as a strong welfare state in Europe, public expenditure biased towards cash transfers over in-kind benefits in the US, or even as central planning to promote forced industrialization and development in the USSR. In contrast to this, with the rise of neoliberal governments during the second wave, the expansion of public expenditure was halted. The welfare state was, to some extent, privatized in the UK and the USA, but also in other less paradigmatically neoliberal countries, as the German Federal Republic and Sweden (Pierson 1996). To conclude, a clear decreasing trend since the 1990s can be appreciated in global public spending in these four countries (OECD 2020b). In addition, another important phenomenon is found in the reduction of the public sector in industrial activities or, in other words, the extension of privatization processes during this second period: a paradigmatic case is that of the UK, which affected key sectors such as railways, gas, coal, and telecommunications.

If we were to adventure the role of institutions in the coming years, it could be related to the new geopolitics that seems to be forming, with the substitution of the USA dominance in the past decades for a multipolar situation, in which China, Arab countries, and India can raise to threaten the American leadership. This could render the redistributive policies of a single country as ineffective. Besides, it could also bring about a weakening of individual rights accompanied by the imposition of autocratic forms of government.

Finally, concerning labor relations, the period that followed the Great Depression was based on the dialogue between trade unions and employers. In America,

the Wagner Act of 1935 pursued the enforcement of trade union's bargaining power to balance negotiation. After WWII, the position of trade unions improved even more, as their role in the mobilization of workers during the war was important. This period was also characterized by high growth rates of real wages and labor productivity, and low unemployment (R. Freeman 1980). Labor supply experienced important structural changes, among which women's incorporation to labor market during WWII should be highlighted. Also, wage composition experienced some changes, as many developed countries started to include fringe benefits like pension plans, paid leave, health insurance, and security social provisions.

On the contrary, during the second wave, the importance of trade unions declined. In both America and Europe, a decrease in trade union density has taken place through these years in practically every country (OECD 2021). Another important change in comparison with the previous wave is the stagnation of real wages. Indeed, labor shares have been decreasing in the G20 countries since the 1980s, even though labor productivity increased (ILO and OECD 2015). Although the smaller role of trade unions could be part of the explanation, this fact can be better explained by the new wave of globalization and the increase of international competence.

Now, regarding the configuration of the labor market after 2010, some conjectures can be made. Based on the aforementioned facts, there appear to be indications of a significant polarization in the future and a diminishing influence of the middle class, accompanied by the emergence of a new stratum of highly skilled workers with substantial compensation. These changes would be related to new occupations with a high technological content (big data treatment, AI programming, etc.), and access to management positions. Additionally, high mobility within and between countries would be another important characteristic.

In short, two clearly distinctive institutional frameworks, in conjunction with the different characteristics at several levels in each of the two analyzed periods, make it difficult to reject the hypothesis of two long waves: 1930–1975 and 1975–2010. Now, there still remains one question to answer: how has the development of these waves and their different paradigms affected income distribution in each one of our two periods? (see Table 3 below for a summary of the characteristics of each wave's paradigms).

5 Income distribution trends in the two long waves

Once we have identified the mechanisms of each period, we should be able to explain the evolution of income distribution in our two periods. According to our scheme, it should be recalled that distribution is the central emergent result of the social system.

As it has been commented in the Introduction, the relationship between growth and inequality is a controverted topic and long-discussed topic, ranging from Kuznets (1955) to more contemporary discussions (Škare and Druzeta 2016). On the one hand, some authors defend a relationship between both facts, without reaching consensus on whether economic growth favors equality (Kakwani 1993; Shatkin 2007) or not (Lundberg and Squire 2003). On the other hand, other economists

Table 3 Paradigms and their characteristics

Long wave	Paradigm characteristics				
	Scientific	Institutional	Role of government	Labor market	Technologic
		Monetary system			
Oil wave (c. 1931–1975)	• Neoclassical synthesis: Keynesianism mixed with neoclassical marginalism	• Gold standard abandonment • Bretton Woods agreements (1944) • Financial regulation: Glass Steagall Act (1933)	• New Deal • Welfare State and public sector expansion	• Employment and wage growth • Role of trade unions • Supply changes: women incorporation	• Mass production and consumption: Fordism and middle class • Television and domestic appliances • Aircraft industry • Oil • Penicillin (1928) and antibiotics
ICTs wave (c. 1975–2010)	• New Classical Macroeconomics • Rational expectations	• Bank money • Liberalization • Objective: inflation	• Government retrenchment	• Wage stagnation • Trade union density decrease • High qualification related to ICTs	• Computers • Telecommunications • Green revolution • Surgery • Plastics

Source: own work.

believe that both alternatives are possible, as shown by empirical data, and thus the relationship between development and inequality reductions depends on the social framework, besides marginal productivities and productive conditions (Bourguignon 1990; Hodgson 1999; Nelson 2008).

In this section, we identify with the latter option, which is coherent with our framework of two waves consisting of different regimes of income distribution (Piketty 2014, 2020). Table 4 below shows some basic indicators of inequality within countries from different perspectives and the seven developed countries of our sample. Looking at this basic data, a first period showing decreases in inequality can be easily observed, in distinction with a second period in which inequality increased. Even when admitting some irregularities, these trends are clear for each one of the waves, both being periods of strong growth and productivity increases. Both waves are also periods characterized by a clear expansionary phase of consolidation of technologies, and another of growth exhaustion and recession. In other words, it does not seem that economic growth is so univocally and exclusively linked to more equal or unequal outcomes of income distribution.

First, let us see how the socio-institutional characteristics of the first period can explain the decrease in inequality that took place during 1931 to 1975. This period was characterized by a strong public interventionism. The reason was that, on the one hand, the excesses of the financial system revealed that it was necessary to establish more controls and regulation to avoid another crash; and, on the other hand, that the crisis had especially affected the lowest incomes, so a policy of recovering these was mandatory. In addition, the paradigmatic productive process of this period, that is, mass production, could only work if a strong consumerist middle class were established. Thus, the recovery of low- and middle-low incomes was crucial for reactivating production. Hence, expansionary policies were established, such as the *New Deal* in the US, or the ambitious project of the welfare state in Europe. Furthermore, a commitment between workers and entrepreneurs to achieve a positive labor environment was also the key for overcoming unemployment in this process of income recovery. The important role of trade unions during the war also contributed to enhancing the perception of these as crucial institutions to reach this level of commitment.

As has already been mentioned before, WWII played an important role in this period, in the sense that the need for reconstruction favored an environment of social collaboration. Piketty (2014) also defends that the destruction of physical capital, which was highly concentrated in the hands of the richest, was another cause in the decrease in both wealth and income inequality. The Cold War might have also affected these trends. The Communist bloc rivaled Western countries for designing the economic system that could achieve higher standards of living within each country, and so, high levels of equality were implied. It might have been possible that the threat of the USSR might had pushed the United States and European countries to implement more egalitarian social programs.

To sum up, the social framework played an important role in decreasing inequality. On the one hand, the role of social democracy and the labor movement was key in creating an environment of cooperation, which consolidated the idea of a strong welfare state, whose objective was to foster a more equal society. On the other hand,

Table 4 Some income distribution indicators for developed countries, 1930–2018

	Top 1% income share				Top 10% income share				Bottom 50% income share				Gini index			
	1930	1975	2010	2018	1930	1975	2010	2018	1930	1975	2010	2018	1930	1975	2010	2018
France	0.17	0.08	0.11	0.10	0.43	0.32	0.33	0.32	0.16	0.21	0.21	0.22	0.35	0.24	0.26	0.25
Germany	0.13	0.09	0.11	0.13	0.38	0.29	0.36	0.37	0.16	0.21	0.19	0.18	0.31	0.23	0.28	0.30
Italy	0.16	0.05	0.09	0.13	0.38	0.28	0.35	0.37	0.21	0.27	0.18	0.16	0.30	0.19	0.27	0.30
Japan	0.19	0.09	0.13	0.13	0.53	0.33	0.44	0.44	0.15	0.20	0.17	0.17	0.40	0.26	0.33	0.33
Spain	0.13	0.09	0.12	0.13	0.36	0.33	0.34	0.35	0.20	0.27	0.21	0.21	0.28	0.23	0.27	0.28
UK	0.19	0.06	0.12	0.13	0.35	0.26	0.34	0.36	0.21	0.23	0.20	0.20	0.30	0.20	0.27	0.28
USA	0.19	0.10	0.18	0.19	0.46	0.34	0.44	0.46	0.14	0.20	0.13	0.13	0.38	0.26	0.37	0.38

Source: own work using data from World Inequality Lab (2022).

social malcontents were a remarkable factor towards the end of the long wave and the subsequent socioeconomic bust (Berkeley and the counterculture movement, the French May of 68, the Prague Spring, etc.). These were the probable answers to a strong frustration due to social improvements during this period being not strong enough as society demanded.

In contrast to this first period, intra-country inequality started to increase after the oil crisis (see Gini indexes in Table 4), which can be explained, at least partially, by the institutional changes that took place then. The need for monetary regulation seemed to be a thing of the past, as it was assumed that a crisis with such implications as the 1929 crash would be difficult to repeat in time. The priority was then to achieve stable inflation rates of around a 2%, a measure that helped to maintain the value of capital. The focus shifted from fiscal policy to monetary policy because not only did price control become more critical, but public expenditures were considered ineffective within the framework of rational expectations. The liberalization of the financial sector derived in the financialization of developed economies: the expansion of the levels of expenditure were highly based on credit expansion, which compensated the stagnation of wages during these years (Barba and Pivetti 2008). The already-established mass consumption of durable goods, based now in lower prices, also enabled to increase consumers' satisfaction with relatively lower levels of income and a certain stagnation of wages. This could have also partially shadowed, but favored, the rising inequality during this period.

Another important facet of liberalization and deregulation is that, as was commented previously, during the second wave, several processes of privatization took place, reducing the weight of the public sector in important activities such as energy, transport, and telecommunications. Thus, several occupations ceased to be provided by public entities, this usually being stable jobs with acceptable retributions.

Labor markets were also liberalized as trade unions were gradually losing importance, wages were stagnating, and unemployment increasing, being now endemic characteristics of a globalized world. The consolidation of the participation of women in the labor market might have been related to wage stagnation, with households perceiving higher incomes, even when the average income per household member might have fallen. Additionally, the rationale behind liberalization and stopping the public support to middle and low incomes also had technological traits: the new information technologies only could have worked giving a push to a new wave of globalization, which could certainly have not happened without liberalizing capital and labor. In fact, some studies have already analyzed the negative traits of this new techno-economic paradigm regarding income distribution, which crystalized, for example, in the notorious debate about the 'bit tax' for redistributing the effects of this technological change (Soete and Kamp 1996).

It can then be concluded that these two long waves presented very different evolutions regarding internal levels of inequality: in the first period, intra-country inequalities decreased, while they increased in the second one. Nonetheless, the complexity of these evolutionary processes precise of more nuanced assertions. An example can be found in the analysis of the evolution of the welfare state. We believe that the inception of the welfare state in post-war societies is a good example of an emergent institutional result of the changes that were being implemented after the Great
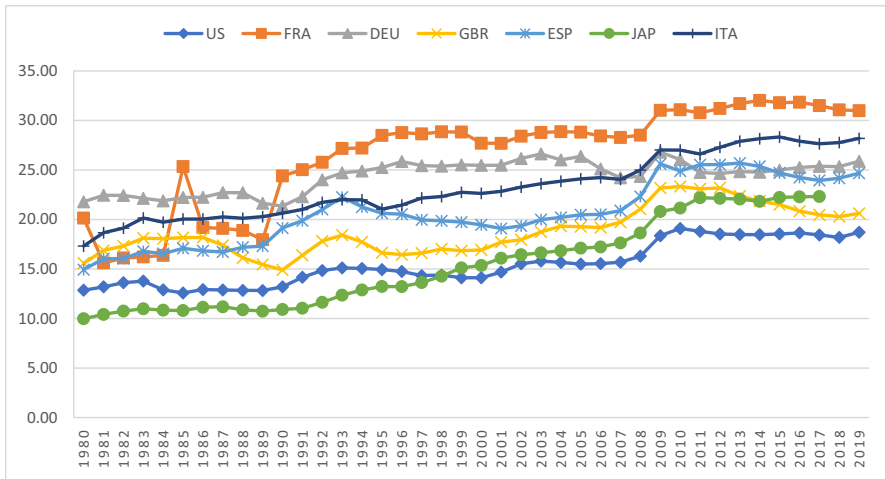
Fig. 5 Public social spending, % of GDP, 1980–2019. Source: own work based on OECD (OECD, 2020c) data

Depression, which favored a higher equality within countries. Despite losing importance during our second wave, it likely contributed to smoothing the increase in inequality after the mid-1970s. In fact, Fig. 5 shows that, in the countries of our sample, total public social spending increased during the second wave, even when public expenditures decreased in total (see Section 4.2). It is worth mentioning, however, that these increases are mainly due to higher expenditures in education and health, which present different characters: on the one hand, increasing education expenditures can be related to technological needs rather than to a willingness for improving the welfare state, as these expenditures end up reducing labor costs for entrepreneurs by improving human capital; on the other hand, health expenditures are more directly related to the welfare state, and can be partially explained by the extension of life expectancy and average population aging in developed countries.

To close this exposition, some brief comments about what to expect in the future concerning social inequality must follow. Our results point to a Juglar cycle starting around 2010. As can be seen in Table 4, the period 2010–2018 is generally characterized by strong increases in Gini indexes. Furthermore, several studies seem to confirm that this period is characterized by increases in intra-country inequality (Carpa and Martínez-Zarzoso 2022; Chancel et al. 2022; Duarte et al. 2022). However, although internal inequalities have intensified during this period, global inequality has slightly decreased since the 1990s, due to a process of international convergence taking place, coinciding with the intensification of globalization processes that are characteristic of our second period. In other words, the improvements in inter-country inequalities went hand in hand with the intensification in intra-country inequality. If the period 2010–2018 is representative of what might lay ahead the road, we can conjecture that the next wave is going to be characterized by a further intensification of income inequality. At the moment, we cannot be cautious enough to perform such forecast, but at least it can be suggested that we cannot take for

granted that a new wave will bring a reversion in income distribution trends, as happened during the change around 1975.

6 Conclusion

The initial inspiration of this research lies in the will to study and reach a better understanding of some questions that many economists are currently considering, namely: do recent economic crises confirm the persistence of long waves? How does long-run growth affect income distribution and social inequalities? And how is it possible that two opposite trends in income distribution appeared in two periods that were both characterized by a strong economic growth? To answer these questions, we have constructed an evolutionary framework heavily inspired in Schumpeter's technological booms, Freeman's long wave theory, and Bunge's evolutionary concept of social system, linked to available empirical information.

Starting from this analytical framework, the explanation of the recent economic evolution since 1929 as a succession of two long-term waves seems reasonable, from our four complementary subdomains, as data and historical events go hand in hand. As we are analyzing social and economic facts, though, we cannot expect this evolution to be determinist, as it is composed of multi-faceted and complex emergent processes. Moreover, our results confirm a high degree of autonomy between economic growth and the evolution of social inequalities. This reveals that marginal productivities cannot exclusively explain the specific pattens of income distribution, and that additional components, such as institutions, are going to be highly determinant.

Although we take some inspiration in Schumpeter's (1939) exposition, the results obtained reveal that the long waves that are deduced from empirical data and the analysis of technological (booms) and institutional frameworks, present a length of 44 and 35 years, respectively, which are shorter than Kondratieff's and Schumpeter's waves of an approximate length of 50–60 years.[6] In a similar way, we find that each long wave is composed of a different number of business cycles: five cycles in the first wave, and four in the second one, which differ from the six cycles suggested by Schumpeter. This analysis is also consistent in cross-country comparisons.

Furthermore, it should be pointed out that we assume that our waves are intrinsically social phenomena, as a result of the complex co-evolution of different dimensions. Therefore, a time extension of our scheme would suggest that a new long wave should have started around 2010 because important changes in the socio-economic paradigm might now be taking place as well. The analysis of the features that are going to characterize the new paradigm leaves another path to follow in future research.

In Section 4, we described both 'wave paradigms' and their changes, to be used in the explanation of long-term income distribution trends. Besides the economic system, we described the interrelated technological, economic, scientific, and institutional sub-domains, to determine a pattern for long-term economic

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[6] By definition, there is also the possibility of long waves being longer than Kondratieff cycles.

evolution. Therefore, for the first wave we established a link between public sector expansion for the promotion of post-war growth, the achievement of an adequate distribution of income and the consolidation of a mass-consumption middle class, and a technological paradigm based on mass production and the use of oil as energetic base. These are the foundations for the reduction in intra-country inequalities during this period. Meanwhile, for the second wave, we found a relation between the coming a new wave of globalization and liberalization and the development and diffusion of ITCs – as international interconnection and global information exchanges could only take place in such an unrestricted institutional context –, with deregulation, cuts in public expenditure, and increases in inequality within countries (although globalization has favored a certain convergence between countries).

On the other hand, our results show a high degree of autonomy between the evolutions of growth and social inequalities, thus, apparently not existing a general correlation, neither positive nor negative, between these two variables. This reveals that institutional components play an important role in determining the specific patterns of income distribution. Each wave has its expansionary and recessive phases, while the evolution of inequality follows two very distinctive patterns in each one of them. Namely, inequality decreased from the Great Depression to the decade of the 1970s, while it started to increase from there up until, at least, the Great Recession. This sheds some light over the open debate about the relationship between growth and income distribution, showing that it cannot be reduced to a study of technologies and productivities.

In short, from our analysis, it first transpires that our current knowledge in economics is still limited, as it is difficult to precisely forecast the development of the economy, both in the medium and the long run. Thus, we should still assume a high degree of uncertainty, as well as the possible development of a new long wave, starting around 2010. The technological boom associated to this last long wave seems to be founded in new generation ICTs (5G, metaverse, artificial intelligence, machine learning, quantum computing, nanotechnology, big data, etc.), in genetics engineering, the general use of renewable energies, or even a new space race. These technologies evolve from ICTs, but are essentially radical innovations that, in our opinion, are forming a new techno-economic paradigm, which would bring about important institutional changes as, namely, in the labor market, a labor demand even more biased to high-skilled workers, the automation of routine tasks, a proliferation of teleworking for these occupations, etc. This wave would then be defined by a new paradigm at several co-evolutionary levels, which we should try to comprehend in order to achieve correct policy designs.

In addition, this scheme would also imply a structure of subjacent intermediate length cycles, and it could be hypothesized that the 2020 pandemics crisis has corresponded to a first Juglar. Moreover, being in the expansionary phase of the new wave, important innovations and a period of strong growth should be expected, despite the convulse situation that the world is experiencing now. Thus, the task of defining the new paradigm is urgent, in the sense that new forms of globalization, different labor arrangements, novel mass consumption patterns, or the diverse technological challenges that might be manifesting now should be properly addressed.

Finally, some policy implications follow from our study. First, the non-deterministic scheme would, which is to be expected, mean that there are no guarantees of achieving perfect equilibriums in real economies, and that economic crises are emergent phenomena that are difficult to foresee, although not impossible. Second, technological evolution now and in the future should be closely screened, as it might give clues about the necessity of implementing structural adjustments, which could soften the harshness of crises. Third, some attention must be also paid to the institutional changes that arise as a result of co-evolutionary forces: in this sense, we might now be experimenting clear changes in the labor market (teleworking, length of the working day, new professional skills, etc.), in the monetary system (cryptocurrencies), or in the future patterns of globalization (re-sourcing processes), and regulations should integrate these changes. Paying attention to these structural changes could also be useful for reverting the long-run trends of increasing inequality in developed countries.

Data availability The data that support the findings of this study are available from the corresponding author upon request.

Declarations

The authors have no competing interests to declare that are relevant to the content of this article. The article is original and is not being considered for publication elsewhere.

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