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Steady change: the 200 largest US manufacturing firms throughout the 20th century

Francisco Louçã and Sandro Mendonça

This paper discusses the existence of structural change in business activity and technological competence among the 200 largest US manufacturing companies throughout the 20th century. The data were taken from Chandler (*Scale and Scope*, 1990) and *Fortune* magazine. The analysis of corporate evolution in used to assess continuity versus turbulence of business organizations in the context of the neo-Schumpeterian long-wave hypothesis. The empirical results show that the giants of the late 20th century are not the same as those at the beginning of that period. Persistence in the sample is very limited. Moreover, turbulence is not smooth, but rather occurs by impulses that affect specific industries, and it has increased over time. Overall, the pattern of corporate entry and industry development is very indicative of the new opportunities emerging with information and communication technologies. This process of open-ended continuous transformation supports the case for putting change at the centre of economic analysis.

1. Introduction

Part of the economist's business is to study changes in populations of concrete economic institutions in real time. This paper discusses the historical evolution of one type of these key institutions, namely the change in the inter-industry patterns of the 200 largest US manufacturing firms throughout the 20th century.

We address three main questions: How (and why) did the number and importance of companies in specific industries shift in this period of time? Do the patterns of entry and exit indicate organizational stationarity or enduring turbulence of a Schumpeterian kind? Finally, can long-term, or any, organizational change be related to the rise and fall of clusters of new technologies?

Corporate evolution is discussed on the basis of statistical and appreciative analysis for 1917, 1930, 1948, 1963, 1983 and 1997 data. For the first three years, Chandler (1990) provides the information, whereas for more recent periods the source is *Fortune* magazine (1964, 1984, 1998). The paper discusses the links between technological turbulence and organizational turbulence, and the empirical analysis looks for evidence of structural change in the patterns of turnover and mobility among giant US corporations. Our research points to a number of results:

- The giants of the late 20th century are rarely the survivors of the early period. There is very little persistence in the population. Only 28 (or 5%) of the total number of companies considered appear in the top list for all six years studied, whereas 267 (49%) appear only once.
- There is, however, some resemblance between the top lists for all the periods, since 'persistent' companies are, on average, higher placed. These companies were typically born around 1880.
- The level of entrants is substantial throughout the century, an average of 70 new companies, or 35%, per data point.

All these observed patterns can be mobilized in favour of the case for long-term corporate and industrial change. But change comes in particular ways:

- Turbulence is not smooth, rather it occurs by impulses that affect specific industries and it has increased over time, with the peaks of entry happening at the beginning and end of our time period.
- There is evidence of enduring inter-industry differentials in terms of both profit and weight of the sectors in total assets and total sales.
- Of the surviving companies since 1917, three sectors (oil, rubber and plastics; chemicals, pharmaceuticals and cosmetics; and electrical and electronic equipment) show consistently robust performance in terms of average industry ranking and the inflow of new firms.
- The performance of the office equipment industry in 1983 and 1997 is remarkable, both in terms of significant new entries and an improved average ranking in terms of sales. This is highly indicative of the emergence of a new techno-economic paradigm stimulated by information and communication technologies (ICT).

We conclude that turbulence is permanent. Change has been the routine for these very important institutions of capitalism. It has been industry-specific. It has also been irregular over time and the data indicate that it has increased in recent years for our population. This dynamism is particularly notable given the stiff barriers to entry built around installed capacity and continuous investment in new technical knowledge by the top companies. These findings, therefore, do not easily support the 'continuity thesis' of Chandler and others, who emphasize the uninterrupted dominance of some large firms in core industries throughout the century. Instead, we argue that these facts are consistent with a pattern of dramatic changes in the dominant techno-economic paradigm, opening windows of opportunity for diversification and for the entry of new firms with the emergence of new sectors.

This paper is also part of a reflection on viable alternatives to more conventional modes of theorizing, such as those proposed by Nelson and Winter (1982) and Freeman (1982). It draws quite heavily on a set of rich empirical and theoretical studies developed by evolutionary economics, neo-Schumpeterian industrial economics, economic sociology, business history and a broad range of contributions on the dynamics of institutions.

Section 2 presents both the focus and the methodology of our enquiry. Section 3 considers the argument and the evidence for and against the 'continuity thesis', which emphasizes the uninterrupted dominance of the same large firms in the core industries of the 20th century. This section concludes with a discussion of some elements in the interpretation of the history of big business in the context of dramatic changes in the industrial structure of the dominant economy, such as has been put forward by contemporary long-wave theory (Freeman and Pérez, 1988; Freeman and Louçã, 2001). Section 4 gathers together the main empirical findings on the ICT-related transformations captured in our database. Section 5 presents the conclusions.

2. Data and methodology

The empirical sections of this paper assess the existence of structural change in the sectoral movements among the 200 largest US manufacturing companies throughout the 20th century. These changing patterns of economic activity constitute a source of insights concerning broader changes in the underlying knowledge base. In order to interpret some of the main trends in the evolution of the top firms, we argue for a reasoned historical approach.

2.1 The quality of data

Cross-sections of the population of the 200 largest US firms are taken at six points in time. Although it has been accepted that Chandler's and *Fortune*'s sets of information are consistent, and other authors have used both sources simultaneously for their work, they have important shortcomings that must be emphasized. As we move back in time, the reliability of statistical information is, of course, more doubtful, and furthermore the classification criteria has shifted over time in response to the change in the nature of the main industries. The first problem cannot be solved, although it can be diminished, as shown in this research, preferably using ratios referring to the same period and, as far as possible, restricting inter-temporal comparisons to those domains for which clear conjectures about trajectories can be argued. The second problem can be addressed in a more satisfactory manner. In the case of the present paper, the selected strategy was to develop a new classification, based on the two-digit Standard Industrial Classification (SIC), but considering complementary information about the core business of the firms and consequently establishing a finer matrix for the analysis (see Appendix). The new industry classification is admittedly very crude in terms of aggregates since companies are classified by sectors according to their principal product group. However, on the positive side, it allows us to keep track of large companies with more than 50% of their activities in these sectors. In several cases, consolidation was necessary in order to measure the real compounded weight of each firm.

A third problem is the change in the definition of some variables: whenever this occurs, it will be indicated. It must also be noted that the choice of the United States is neither innocent nor inconsequential: with a large market and no wars at home for the period we are considering, the United States lived through an exceptional form of

Table 1 Data points in the long phases of expansion and decline

Expansion	1917, 1930, 1948
Peak	1963
Decline	1983, 1997

expansion of the techno-economic paradigms dominating the third and fourth long waves. Furthermore, its role in the Cold War period and its military, political, financial and economic leadership during the third and the fourth long wave from approximately 1895 to the present generated a very specific combination of state investment and scientific innovation that moved the technological frontier.

Given the chosen years of our data set, the intervals vary quite a lot: there are 13, 18, 15, 20 and 15 years between successive points of information. There is a mixture of statistical and theoretical reasons for the choice of these periods. For the first three, they were simply the only data points available. They provide detailed information of the beginning of the decline of the third long wave, of the moment of impact of the 1929 crisis, and of the dynamics of reconstruction and the expansion after the Second World War. The other years were optional: 1963 is one of the years of the peak in the period, 1983 and 1997 are both part of the long decline, although in the recent period the US economy and consequently some of its most important firms had already been in continual, although restricted, expansion for some years. We have, as a consequence, two years of decline and two years of expansion, one year of international deceleration but of national expansion, and one year at a turning point (see Table 1). The possible results of this enquiry are at best merely indicative, since this 'population' cannot be thought of as a 'sample' of something else.

2.2 The methodological options

This paper centres on the appreciation of patterns of evolution and detects the major changes occurring in the 20th century, as part of the test of the argument about the importance of structural change in economic history.[1] This limited purpose is constrained by the very nature of the available data set: identified by a very narrow set of variables, these populations of large firms are statistically inadequate to test conjectures about degrees of monopoly or forms of competition (Stigler, 1969: 338). Furthermore,

[1]Unlike Dunning and Pearce (1981), this paper does not develop a research into the international structure and internal exchanges and strategies of the firms, nor is it based on information on R&D and innovation. Unlike Chandler (1990), it does not address the quite relevant problem of diversification of production. This work is also not related to the long-standing debates of Hart and Prais (1956), Hannah and Kay (1977), and others about the relationship between industrial concentration and takeover activity.

they do not provide relevant information for the identification of the many important relationships that develop between them.

The method and the conclusions depart from some of the established theories, in particular from four of the most influential. Firstly, the paper does not follow the ecological theory of organization (e.g. Hannan and Freeman, 1993), which stresses the role of organizational inertia and a Lamarckian view of small adaptive firms responding to changes in the environment. We consider that the factors for change are not essentially or, at least, not predominantly the costs and (measurable) risks, but competition based on profit accumulation, technologies and knowledge. We are interested in change, not just in inertia, and this is also a factor of differentiation in our approach in comparison with the 'old institutionalist' tradition (e.g. Hodgson, 1998).

Secondly, the paper does not follow a view of more or less uniformly informed and strategically victorious managers, but instead emphasizes the diversity, emergence, and success or failure of firms and industries. Furthermore, the social constraints in the history of concrete firms cannot be underemphasized: Andrew Carnegie cannot be understood without reference to the Homestead strike (see also Williamson in Chandler and Daems, 1980: 196) and the same may be said of so many other aspects of his life and deeds. The rationality postulate imposes an internal story and a narrowly abstract vision of real life evolution that is not compatible with the broader range of historical information being dealt with in this paper. Essentially unpredictable opportunities, radical innovations, exogenous changes and the emergence of entirely new products or forms of production contributed to the definition of the dynamics of industrial capitalism. In this story there are victors and losers: it is a result of a *post hoc ergo propter hoc* fallacy to consider that only the contemporaneously known big firms existed and dominated their industries (Alford, 1994: 633). The overstatement of the survivors is certainly a feature of our memory, but not necessarily true.

Thirdly, the paper challenges the conventional wisdom of the centennial evolution of these firms that insists on the stability of the population. In this respect, we follow David's (1991) and Granovetter and McGuire's (1998) point about the suppression of diversity as the result of concrete social processes,[2] although simultaneously stressing alternative examples of the generation of new knowledge and new industries, providing the opportunity for new entrants into the restricted 200 club.

Fourthly, the paper assumes that a historical and appreciative theory, based on concrete statistical information, is one of the best available tools for explaining these patterns of evolution, since the object is quite complex and the hypothesis of atomistic

[2]Both Granovetter and McGuire's, and Paul David's studies were conducted into the establishment of standardization in the US electricity industry: in 1878–1885 there were more than 1500 independent systems for the production of electricity, and in 1891 more than 2000 independent firms were established in the United States. In 1929, only a few big firms already dominated the industry and standardization was one of the tools for that concentration. The authors show how the strategic although myopic behaviour and the informal power of a limited number of players were decisive for the imposition of the future pattern of the industry.

agents is irrelevant. Consequently, this assumption stands in contrast with traditional growth accounts, such as of endogenous growth theory, which take aggregates as the privileged representation of empirical information; we follow the alternative rule that one cannot understand the picture without the detail. The awareness of trends and varieties in macroeconomic environments remains crucial for our analysis.

Departing from the aggregate production function studies, authors such as Freeman and Pérez (1988) have used the concept of the techno-economic paradigm to describe those changes of a structural kind that are induced across the whole economy by new clusters of important technologies. A new techno-economic paradigm or technological style refers to the emergence of a new method of producing, distributing, and managing an ever-broader spectrum of goods and services. The long periods of sustained growth and change ignited by a new cluster of technological resources and organizational processes are known as *long waves of development*, a concept developed from the pioneering work of Kondratiev and Schumpeter.

In a recent restatement and empirical assessment of the theory, Freeman and Louçã (2001) extend and apply this framework by considering a third major industrial change, the information revolution. The key radical innovation behind its rise was the development of the electronic microprocessor. This is the core input for a new wave of expansion, and its characteristics are (i) a falling relative price, (ii) universal availability and (iii) a broad range of applications. The producers of core inputs, the motive branch, are the semiconductor industry. Those new industries producing or delivering the most emblematic applications of the new paradigm are the carrier branches (computers, software and telecommunications industries). We shall adopt these conceptual constructs in our analysis.

3. Damned to survive? The continuity thesis and the contradictory empirical evidence

In this section we consider the argument that the largest firms are essentially a stable population throughout the century (Section 3.1), and challenge this hypothesis on the basis of contradictory evidence from the history of the world's 100 largest firms (Section 3.2) and the 200 largest US manufacturing firms (Section 3.3).

3.1 The reasons for continuity: cumulative investment and knowledge

The continuity thesis emphasizes the importance of stability among economic organizations. Based on an extended survey of the foundation year of the largest 500 US firms recorded in *Fortune* in 1994, a study by the Harris Corporation recently concluded that there was a 'remarkable endurance and adaptability of major firms as institutions in a world that has seen frequent, rapid, and tumultuous change' (Harris Corporation, 1996: 72). In short, in an economic world dominated by change, big business has been one of the pillars of stability.

But, in spite of this unrepentant conclusion, the survey commissioned by the Harris Corporation, to which Chandler and others contributed**,** presents mixed conclusions.

The centennial firms are certainly important: they represent 39% of the population. And if we consider those firms founded between the 1880s and the 1920s, we find approximately 50%. Yet some 16% were founded after 1950, and the pattern of the emergence of new giants is very indicative of the new opportunities related to the ICT revolution, since several of them were created in the integrated circuits and computer industries (Intel in 1971, Apple in 1976, Compaq in 1982). This evidence highlights three very relevant characteristics of the giants: (i) approximately half of the larger firms were created during the second industrial revolution: (ii) the first movers create barriers to entry, but (iii) new opportunities are still open for entrants in new industries and they may rapidly become part of the club.

An argument by Chandler presents the case that (i) and (ii) are to be explained by the accumulation of capabilities in the framework of early oligopolistic competition and the constructed advantage of large-scale investments in physical and human capital:

> By World War I the major players in the capital-intensive industrial oligopolies had established themselves. Many of these firms remained the leaders in their industries for the next half century. Some would disappear by merger, and others would drop off the list of the top 200 as new technologies brought new industrial leaders to the top. Because of continuing oligopolistic competition, ranking in terms of sales, market share, and profit within an industry rose and fell. Nevertheless the first movers, those that made the largest initial investment in capital equipment, continued during the following decades to make large scale investments in physical capital, in most cases funded by retained earnings, and to be among the nation's major employers of industrial workers. The barriers to entry became so high that few challengers entered the oligopoly. These enterprises thus became learning bases for further development of products and processes. They remained at the core of a network of suppliers, dealers, and other related firms. (Chandler, 1997: 76)

For Chandler, this form of oligopolistic competition is at the origin of cumulative learning and leads to the construction of specific organizational capabilities, which generate high barriers against new entrants for a long period, allowing for the persistence of oligopolistic profits and therefore fuelling continued growth (Chandler, 1994: 3). At the same time, oligopolistic profit lies at the heart of the capacity of these firms to prolong their advantage through large investment in R&D and the creation of entry barriers due to established advantages in scale economies.

The work of Patel and Pavitt (1994, 1997) followed this direction. In what can be seen as a more technologically oriented version of the continuity thesis, these authors conclude that corporate technological profiles, i.e. firms' portfolios of competencies as revealed by patent counts, are essentially stable over time. Bounded rationality and path-dependence in technological search create an essentially rigid channel for capability accumulation at the micro level. We are told that, because radically new

knowledge is unfamiliar, hard to duplicate and complex to manage, creative accumulation may predominate at the macro level (Pavitt, 1998). Consequently, in the long run, incremental change tends to prevail over sudden, dramatic change.[3]

3.2 Empirical evidence from the world's 100 largest firms

Unlike the authors just considered, others point out that certain pieces of evidence suggest an alternative conclusion. This is the case with Audretsch:

> One of the most startling results that has emerged in empirical studies is that entry by firms into an industry is apparently not substantially deterred or even deterred at all in capital intensive industries in which scale economies play an important role. (Audretsch 1997: 65)

This subsection considers some evidence to support these alternative conclusions, namely the research undertaken by Leslie Hannah into the evolution of the world's 100 largest firms.

Hannah considered the manufacturing and mining companies of the most developed industrial nations, and compared the 100 largest companies in the 1912 and the 1995 lists. The 1912 list is consistent with the results of the research mentioned earlier by the Harris Corporation. The average age was 32 years, i.e. the firms were created on average in the 1880s. But the trajectory from 1912 to 1995 suggests a remarkable conclusion: only 25% of firms remained independent or grew from 1912 until 1995, and, of these, only 19 were still in the top 100 of 1995—i.e. 'disappearance or decline was nearly three times more likely among the giants than growth' (Hannah, 1999: 271). Furthermore, Hannah concluded that industry location was more relevant than nationality for explaining the pattern of evolution (*ibid.*: 15).

Although there is more diversity of performance within than among industries, the surviving giants 'were exclusively in "new" growth industries: petroleum, electricals, chemicals, copper mining, and branded products' (Hannah, 1998: 63). These new sectors are simultaneously those that present the highest intra-industry consistency of performance, as measured by the coefficient of variation of the firm's market capitalization.

It is also necessary to emphasize that the history of particular industries fits in with this vision of dramatic discontinuities amidst the permanence of some giants. A telling example is that of the automobile industry. Although mass production was soon adopted by carmakers (since 1902), recent research into the role of innovations in the

[3]The contributions of Patel and Pavitt use samples drawn from the SPRU-OTAF database, benefiting from its advantages whilst also being restricted by its built-in limitations. This database includes patents for 463 of the world's largest companies since 1967, distributed according to principal product group, and represents a huge effort of consolidation of 4500 subsidiaries and divisions taking into account different assignee names. However, the characteristics of the data are such that a degree of 'contrafactual' analysis is involved, since corporate entities are assumed to exist in the periods considered as if they were always the same combination of divisions and subsidiaries throughout time (see von Tunzelmann, 1999).

development of all 2149 firms involved in the industry from 1885 until 1981 (Carroll and Teo, 1996: 630) points out that product differentiation is a recent feature of competing strategies (post 1950). This apparently lends support to the explanation of the outcome of competition dynamics by organizational inertia, following Hannan and Freeman (1993), but one must also take into consideration the fact that only very few producers survived the initial period of intense competition and that such a period defined the contours of the industry for the century.

In view of these results, one may wonder if the easy acceptance of the continuity thesis is not related to the image traditionally given to survivors, the failure to mention those firms that are excluded, and the changes the survivors themselves went though. This distorts our perception of the global evolution of the population and over-emphasizes the importance of the remaining giant firms.

3.3 Empirical evidence from the 200 largest US manufacturing firms

The discrepancy between these contending views justifies the recourse to a more manageable, comparable and extended set of information. This is why we considered only the US and the largest population we could obtain from secondary sources: the 200 largest manufacturing firms, which are identified by Chandler for 1917, 1930 and 1948. The series was then prolonged with *Fortune* data for 1963, 1983 and 1997. As a consequence, we obtained a population of 543 firms for the whole period.

In this subsection, we submit that the history of these industries and firms may be better understood if four main periods are considered: the foundation years, including the great wave merger at the turn of the century, the decline of the third long wave (1913–1939/41), the expansion of the fourth long wave and then its decline (1940–1973, 1974–). Moreover, this method of periodization will help us later on with the main task of the paper: to discuss the changes and possible discontinuities that took place in the late 20th century and their relationship to the emergence of a constellation of new ICTs.

The persistence in the series is very limited: only 28 firms appear in the top list for all six of the years. These are the 'persistent' giants, which were founded at the turn of the century or benefited from mergers during that period (see Table 2).

But while 28 firms appear in all lists, more than half of the firms constituting our population (266) appear only once. The frequencies of presence in the top list is shown in Figure 1. Furthermore, the 'persistent' firms are, on average, higher placed in the general ranking, as expected and shown in Figure 2.

Figures 1 and 2 paint a picture that is inconsistent with the continuity thesis. Only a small proportion of the giant firms maintain their position in the ranking, and new entrants are able to quickly establish themselves at the top. As Figure 3 shows, the level of entry is very important, although fluctuating.

Our cross-sections show a declining trend in entry from a peak of 87 new companies in the 1930 list, i.e. 48% of the whole population, to a minimum of 45 entrants in 1983, corresponding to 23% of the 200 list. A major shake-up in the population happens

Table 2 Birth dates of the surviving giants

Company	Date of foundation and *most important merger*
Alcoa	1888
Amoco	1889
BestFoods	NA
Bethlehem Steel	1857 (*1902*)
Borden	1857 (*1899–1904*)
Coca Cola	1886
Deere	1837 (*1911–1912*)
Du Pont	1802 (*1895–1905*)
Eastman Kodak	1884 (*1903*)
Exxon	1870
Ford	1903
Fortune Brands	NA
General Electric	1892 (*1901–1902*)
General Motors	1908
Goodyear	1898
Inland Steel	1893 (*1954*)
International Paper	1898
Navistar	1846 (*1902*)
Owen Illinois	1903 (*1929*)
PPG	1883
Procter and Gamble	1837
Quaker Oats	1891
R. J. R. Nabisco	1875
Sun Oil	1886 (*1895–1904*)
Texaco	1902
Union Carbide	1886 (*1917*)
Unocal	1890
USX	1901

again on the latest date with 80 new companies joining the club.[4] Computing the average for the whole period, for illustrative purposes only, it is as if 70 new companies entered at each of the data points, representing a successive renewal of 35% of the top 200. The beginning and the end of the series are the moments with the highest intensity of entry: 1930 and 1997 account for nearly half of all new entrants in the database. There were also a total of only seven movements by companies away from their previous industries into new ones, however, six of which occurred in 1983 and 1997.

[4]As we shall see in Section 4, the office equipment sector accounts for a large proportion of the new movers.

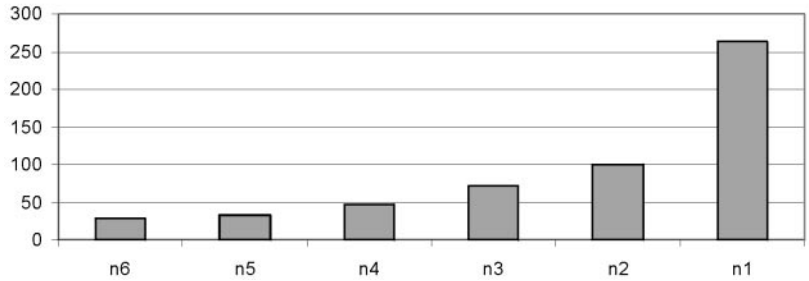

Figure 1 Frequency of presence in the top list. n6 = a company appearing six times in the list, n5 = five times, etc.

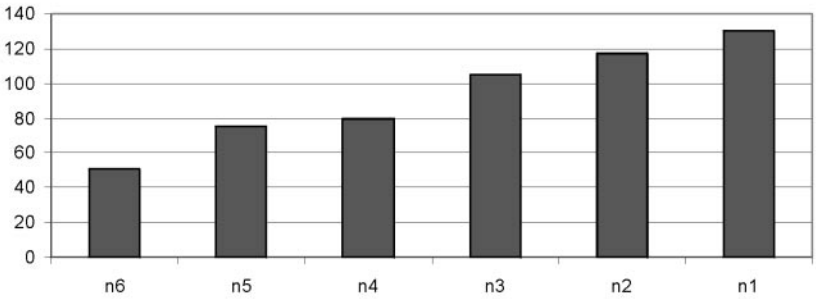

Figure 2 Average rank according to the frequency of presence (persistence).

Figure 3 New firms entering the population.

The moments of high turbulence coincide with the rise and decline of the fourth long wave. Peaks of entry appear to be associated with times of transition. This implies that persistence is not a guaranteed status for large industrial firms. Turbulence is the norm, while bursts of new entries seem to be situated at specific points in time.

Other studies confirm this result and argue that turbulence may even have increased in the latter decades of the century, affecting at least one-third of the population. Friedland (1957) studied the 50 largest US industrial firms for 1906, 1928 and 1950, and concluded that 67% of the 1950 list were already present in the list for the first period, while one-third were not. Audretsch computed the time needed to replace one-third of the *Fortune* list (the 500 largest firms) and concluded that this would take two decades in the 1950s and 1960s, whereas in the 1970s it would take one decade and, more recently, in the 1980s, not more than half a decade would be needed to replace that proportion of the universe (Audretsch, 1997: 50). Drawing from a confidential internal report prepared for Shell managers in 1980, de Geus (1997) contends that one-third of the *Fortune* 500 list of 1970 had already disappeared by 1983, having been bought, dismantled, or simply gone out of business. Recent research by other authors confirms this picture of instability: 41% of *Fortune*'s top 300 disappeared from the list in the period from 1963 to 1987 (Simonetti, 1996); 35% of the top 100 British firms did not survive between 1983 and 1993, whereas for French and German firms the rates were 34% and 22% respectively (Whittington *et al.*, 1999).

This image of turbulence in the highly oligopolistic and protected niche of the larger firms refutes the continuity thesis.

3.4 E neppure si mouve*: preliminary remarks about the phenomenon of long-run corporate turbulence*

The development of large industrial joint-stock companies is historically a recent phenomenon. By the 1870s, such large firms were scarce, either in the US or elsewhere in the world. But by 1920 'big business had already became the most influential non-government institution in all advanced industrial market economies' (Chandler and Daems, 1980: 2–3), and thereafter it maintained its dominance throughout the century. Considerations about the further development of such large-scale forms for the organization of production involve not only institutional factors, but the nature and sequence of changes in technology.

As we are considering the largest industrial firms in the United States, mention must be made of the fact that these firms were and still are part of a general movement towards the combination of industrial and financial capital. In 1917, when we have the first data set, these firms were not only productive giants: they were also firmly established as part of the alliance between industry and Wall Street, and they were the result of a wave of mergers that took place in the period between the 1880s and the outburst of the First World War, and in particular between 1898 and 1903. Three hundred firms disappeared through mergers every year in that period, leading to the creation of the dominant firms.[5] This was only possible thanks to the functioning of an

[5]In petroleum Standard Oil and Texaco; in rubber, US Rubber-Uniroyal and Goodyear; in metal and metal products, US Steel, Bethlehem Steel, American Smelting and Refining, Jones and Laughlin Steel, Anaconda Copper, Phelps Dodge, International Nickel, National Lead and American Can; in electricity, General Electric, Westinghouse; in food processing, American Sugar, Nabisco, United Fruit, Swift and

active capital market—one of the most important innovations of the second industrial revolution[6]—and the mobilization of finance capital *per se*.

When we take a long-term perspective, the appearance and diffusion of innovations turns out to be a very uneven process across industries, and certain combinations of radical innovations may even give rise to phenomena described as *technological revolutions*. One example is that of the second industrial revolution, leading to the third long wave of capitalist development. As both Chandler and Hobsbawm persuasively argued, the major impact of the railroadization of the US was not the opportunities directly created for investment and upstream orders, but the spread of professional management, including science-based technology, changes in the qualification of the labour force, the regulation of markets, the use of new materials, new devices and techniques, along with electrification and new forms of using and disseminating information. The scale-intensive, capital-using, natural resource-consuming, knowledge-augmenting, learning-enhancing firms that dominated this techno-economic paradigm were seen as the leaders of the world. However, the fortune of even such large and successful corporations is not guaranteed forever.

4. Structural change and the identification of the phases of development of modern industrial capitalism

The data set we are considering does not allow for general conclusions on the dating and the structure of the long waves, but it provides some evidence on the dynamics of industrial patterns that is compatible with our hypothesis.

4.1 Patterns of structural change

The intense period of capital accumulation from the First World War until the end of the Second World War, in the declining period of the third long wave, provided the framework for the expansion of these firms and stabilized the oligopolies (three automobile firms—Ford, General Motors and Chrysler—and the seven sisters in petroleum production and refining), although some niches remained open for entrants (e.g. trucks). Like the railroads in the previous period, automobile production, as well as electrical equipment and chemicals, provided the inputs for progress in mechanization, management, social organization of production and the spread of new commercial techniques for the whole industry.

By 1963, at the peak of the fourth long wave, the distinctive capacity for generating and retaining larger profits in the motive and carrier branches associated with the new techno-economic paradigm was already obvious, although the industries were still

Co. and Armour; in tobacco, American Tobacco; in chemicals, Du Pont; in machines and tools, International Harvester, Singer and Kodak; and in others Pittsburgh Plate Glass, Allis-Chalmers.

[6]This is, by the way, one of the crucial arguments for not restricting our argument to the schedule of the successive 'industrial revolutions', and for arguing in favour of a systemic approach to innovation and change within a broader social framework.

dominated by the large producers based on mechanical and chemical processes. Between 1983 and 1997, this trend was reinforced as computer and office equipment industries moved centre stage in our indicators.

For the whole of the period we are considering, the graphs in Figure 4 show the evolution of the share of the firms of four sectors in the total assets of the universe.

Firstly, and as might be expected, the graphs in Figure 4 show that the production of metal products is specifically a feature of the third long wave (the right hand side of the graph). Secondly, the importance of oil production marks the third and the upswing of the fourth long wave coinciding with the development of the cluster of industries based on chemical processes or providing the inputs for their development (rubber, oil, primary metals, glass and paper) which became more capital-intensive and the primary drivers of capital accumulation in the United States—they represented approximately 40% of added value in US manufacturing at that time (Chandler, 1997: 70). Thirdly, the figure shows how the chemical/pharmaceutical/cosmetics industry retained its share and adapted over time. Meanwhile, there was also an important transformation in the

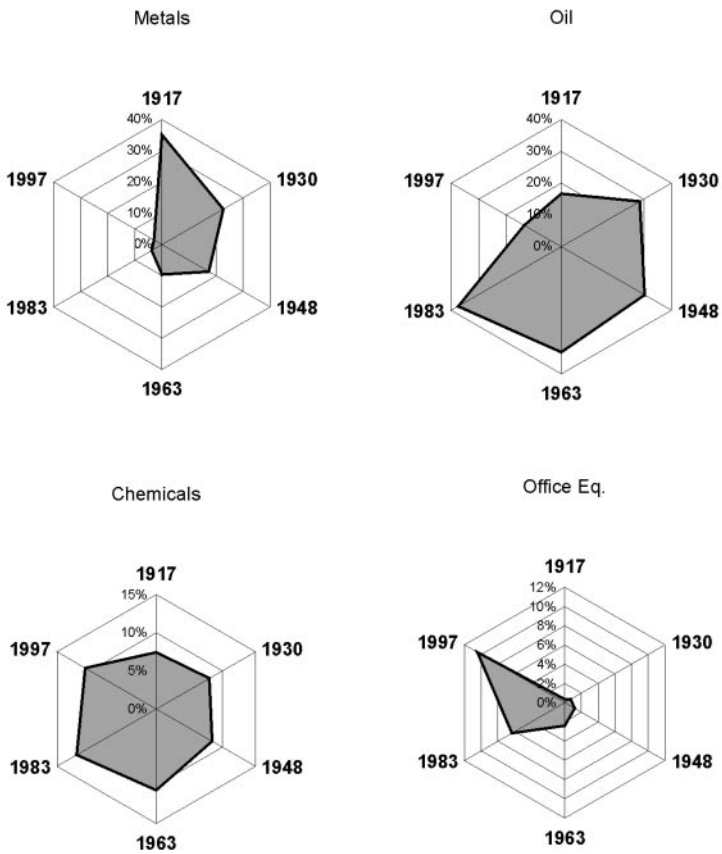

Figure 4 Evolution of the share of sectors in the total assets of the 200 firms.

methods used in commercializing products with the development of new marketing techniques and large-scale retailing services, but that is not part of this research.

One final point, and perhaps the most striking feature arising from a comparative analysis of the graphs in Figure 4, is the 'take-off' of the office equipment industries during the decline of the fourth wave. In 1917, these industries represented 0.4% of total assets in the sample, by 1963 they amounted to 2.4%, rising fast from 1983 (6.3%) to 1997 (10.5%). Sales revenues in the sector accompanied the steady increase in assets, 2.1% in 1963 and 12.6% in 1997, whilst profits soared. This sector, which had a share of 2.6% of total profits in 1963, accounted for a share of 18.6% by 1997.

As can be seen in Figures 5 and 6, profitability in the sector was remarkably higher than in manufacturing as a whole. For leading firms in the new-technology sectors, accumulating profits was imperative as they attempted to pay back their previous loans

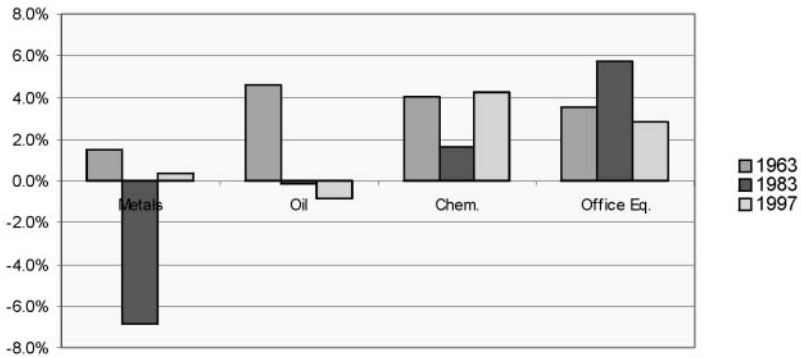

Figure 5 The comparative evolution of profits in relation to assets for the metal, oil, chemical and office equipment industries.

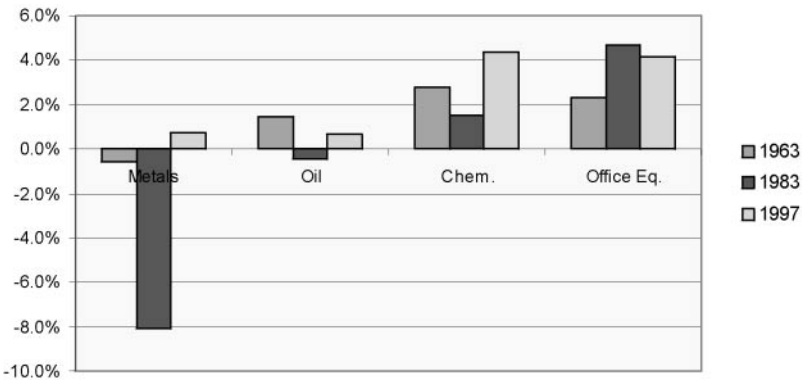

Figure 6 The comparative evolution of profits in relation to sales for the metal, oil, chemical and office equipment industries. (*Fortune*'s original data label is 'total profits' for 1967, 'net income' for 1983 and 'total profit' for 1997.)

Table 3 Asset concentration and performance in 1963

		% of total assets	% of total sales	% of total profits
1963	5 largest =	18.3	22.5	28.9
	10 largest =	27.5	30.8	40.2
	25 largest =	39.9	46.3	55.5
1983	5 largest =	14.4	21.2	29.4
	10 largest =	23.1	32.3	42.6
	25 largest =	38.3	49.2	61.2
1997	5 largest =	32.0	23.0	21.8
	10 largest =	39.6	33.0	31.7
	25 largest =	52.5	50.0	54.3

and cement their leadership by influencing standards, intellectual property rights management, scale economies and a variety of other means. Furthermore, the relatively limited importance of assets and sales of these in relation to the motive and carrier branches of the previous periods of expansion explains why the transition from the continuing decline to the next phase of upswing is so slow and contradictory. In other words, the upswing faces a mismatch and cannot be generalized to the whole economy. The emergence of a new mode of development is far from complete.

We can see further evidence of change in industry performance if we compare asset concentration—barriers to entry—and the capacity to generate returns, as shown in Table 3. The widening gap between asset concentration at the top and the capacity to generate revenue depicted in the three tables below allows us to conclude with von Tunzelmann (1999: 789), but contrary to Chandler and Hikino (1997), that, in spite of their physical capital intensity, large companies at the very top are failing to keep up with a shift in competition towards a model based on high knowledge intensity. Although precise calculations of profits are generally quite difficult to make due to the quality of the data available, it is still possible to maintain that the swings in profitability offer confirmatory evidence of our main claims. The increases in concentration in sectors established in the fast-growing mass-production industries of the fourth long wave, namely oil-related sectors, were not enough to retain relative profitability.

In order to discuss further the data of asset concentration and performance shown in Table 3, it is prudent to conduct some sensitivity analysis. For this purpose, a close inspection of the top 25 companies provides some useful complementary information. According to the data,[7] for instance, the oil, plastics and rubber sector dominated that

[7]Not shown for reasons of economy of space.

list in 1983 and accounted for 51% of the total profits of the top 25. By 1997, the number of companies from this sector had fallen to five, although they still maintained a 22% share of total profits. Conversely, the office equipment sector became the second largest contributor to the total profits amassed by the 25 largest companies in 1997 (after oil, plastics and rubber) with a share of 20%. For the first time, IBM was accompanied in the top 25 by other firms from the sector: Hewlett-Packard, Intel and Compaq. This is clear evidence of a change in the pattern of profits, in spite of the huge advantage of established firms in terms of capital and research facilities. Our argument therefore is that groups of firms periodically entered the list of giants based on their competence in emerging core technologies. This has occurred with both electrification and motorization, but the ICT revolution offers the strongest confirmation of this.

Table 4 adds to this picture of structural change by confirming that the ICT companies are essentially 'newcomers'. The office equipment sector stands out through its distinctive behaviour at the last two data points after remaining a dormant sector for most of the century with an average of around four companies in the 200 club. Things started to change in 1983 when the entry of four new companies[8] boosted the industry's average ranking in terms of sales from the 122 (11th place among our 16 sectors) in 1963 to 69 (second place) behind only the motor vehicles and parts sector. But it was in 1997 that its behaviour became quite remarkable. With a total of 20 entrants, 19 from outside the top 200 plus one from another industry,[9] it was by far the industry with the highest number of entrants ever.[10] The industries with closest performances in terms of the maximum number of entrants at a data point were oil, plastic and rubber in the 1930s with 14 entrants; chemicals, pharmaceuticals and cosmetics during the 1940s with 11; and electrical and electronics equipment during the 1960s with 11. The food, beverages and tobacco sector, a category loosely corresponding to Hannah's branded products, has an impressive performance for the first three years in the series.

Table 4 shows how organizational turbulence changed across sectors and through time. We observe that the peaks of entry seem to be associated with moments of transition. Indeed, the sectors that have more entries in the years of high turbulence are those industries associated with the rise of the fourth long wave in the 1930s and the ICT-related industries in the 1990s.

When economists refer to structural change, they often mean a change in the share of the sectors of an economy. Here we can notice some significant changes in the patterns of business activity in our population of companies. But evolutionary

[8]One of which, Honeywell, already in the top 200, had moved from the scientific, measuring, control and photographic equipment sector, as indicated by the *Fortune* classification system.

[9]Xerox, who was classified in the scientific, measuring, control and photographic equipment in 1983.

[10]The separation between more traditional electrical equipment companies and ICT-related companies is not always easy especially for the last two of our data-points. Still, ICT-related changes are likely to be underestimated. For instance, Lucent Technologies and Motorola, notorious for their ICT product offerings in the late 1990s, were classified by *Fortune* in the electrical and electronic equipment sector in 1997.

Table 4 Sectors having had 10 or more entrants at a data point

	1930	1948	1963	1983	1997
Food, beverages and tobacco	**16**	**10**	**15**	5	7
Chemicals, pharmaceuticals and cosmetics	**10**	**11**	9	**11**	7
Oil, plastic and rubber	**14**	7	4	**12**	5
Electrical and electronic equipment	1	3	**11**	6	7
Aerospace	2	4	**10**	1	–
Office equipment	3	–	–	4	**20**
Total new entrants in the top 200	87	65	73	45	80

economists are also interested in qualitative changes; unfortunately these are usually more illusory and, as in the case of our database, harder to measure.

4.2 A long process of transformation: a discussion

There is a dramatic discontinuity that is of interest for this survey, namely why did the electrical equipment manufacturers miss the chance to develop the computer industry? Indeed, it was left to IBM (punch cards), Remington (typewriters), NCR (cash registers), Burroughs (adding machines) and Honeywell (heat regulators), i.e. producers of machinery, to seize the opportunity and expand into the new business. And when, later in 1965, the producers of electrical machines (GE and RCA) tried to catch up, they were quickly forced to leave the market (see Box 1).

Our argument is that this is not merely an exception, but a pattern of evolution which challenges the established firms, leading to their adaptation—be it a success, as in the case of producers of machinery, or a failure, in the case of the early electrical producers—or to the emergence of new firms from scratch. While emphasizing the dominance of big business from the second to the third industrial revolution, Chandler detects this phenomenon, although he dubs it an exception to the path-dependent evolution:

Box 1 The evolution of the electrical industry

The history of General Electric has been the subject of extensive research and it is not necessary to comment extensively on it. But it provides a magnificent illustration of our argument: several of Edison's businesses merged in 1889, creating the Edison GE Co.; and Morgan took control of this in 1892, at the time of the merger with Thompson–Houston Electric Co. GE created the first R&D laboratory in 1901 and the first worldwide industrial facility to be directed by a scientist.

One decade later, the world market was dominated by four firms (GE, Westinghouse, Siemens, AEG) with a complex network of collaboration in patents and research.

> Just as the new technologies associated with the Second Industrial Revolution came to be dominated by large enterprises, so too the new industries associated with the Third Industrial Revolution fell under their domination. In this respect, growth has been 'path dependent'. Indeed, except for electronic data-processing technologies, based on the transistors and integrated circuit, the new technologies were commercialized by large well-established industrial enterprises rather than by start-ups, as had been the norm before the 1940s. (Chandler and Hikino, 1997: 33)

In the same sense, our argument is that this major brake in path-dependence was possible despite the learned capabilities of the major firms, the oligopolistic structure of the market, and the overwhelming advantage in capital, research facilities and technological power of established firms (see Box 2). These major firms could not overcome the inertia of their previous development, and the increasing returns obtained in the first phase of the general trajectory of the second industrial revolution became limiting factors in their ability to capture innovations and the changes both in demand and in opportunities for the supply of new products. This process of transformation took a long time, and this is one of the explanations for the shape of the long wave: 'A common feature to the development paths taken by major new technologies is that quite unforeseen capabilities and uses are discovered along the route' (Nelson, 1998: 25).

Consequently, the role and fate of the computer and office equipment industries are at the core of any explanation of the general trends in development—just as they are the *experimentum cruxis* of the continuity thesis. ICT producers, as we would call them today, are essentially freshers in the top 200. Indeed, when the shift from mechanical devices to mainframes was made possible, many of the old giants reacted accordingly.

Box 2 IBM, a story of success

Computing Tabulating Machines (CTR) was formed in 1911 through the merger of the Computing Scale Co. (founded 1891), the International Time Recorder Co. (1889) and the Tabulating Machine Co. (1896), with very widespread competencies in different mechanical fields. The second was the world's largest producer of time clocks. The third gained prominence as the originator of important demand management innovations. It was founded by Charles Flint, a Wall Street financier, arms dealer and agent of the tsar during the Russian–Japanese war.

From 1914 forward, the firm was run by Thomas Watson—initially a salesman at NCR. From 1346 employees in 1914, CTR (IBM since 1924) had grown to 72 504 employees when Watson died in 1956. But Watson was not always a leader in technological innovations: during the 1940s, he had a disagreement about the future of computers with his son, who had been supposed to take over from him.

Although IBM dominated the world market in 1969, the lack of investment in microcomputers allowed for new entrants, who represented 30% of the total market by 1980.

In 1950 Remington bought the firm created by Eckert and Mauchly, previously at Pennsylvania University, who had built ENIAC in 1946 and launched UNIVAC. This new machine replaced IBM in the Bureau of Census, a powerful blow to which IBM reacted by hiring 3500 engineers and technicians in six years. In 1952 the new IBM 701 and 702 were placed on the market; in 1954 the IBM 704 and 705 followed; and, in 1964, IBM 360 established the pattern in modular compatible computers. The conclusion was that IBM triumphed thanks to its heavy investment in R&D, and Remington failed due to its lack of investment in the same area. A parallel story to the Remington–IBM duel is that of Fairchild and Texas Instruments (TI), which dominated the planar silicon transistor technology in 1961: Fairchild (see Box 1) invested in research, but TI was not only able to undertake intensive research, but also to exploit the learning curve and consequently to obtain larger profits and dominate the world market in the early 1970s[11] (Malerba and Orsenigo, 1996: 75).

IBM entered the new market, as did Burroughs, Univac Rand, NCR, Control Data, Honeywell with General Electric, and RCA. But some of these firms did not meet the next challenges. Then again, new entrants used the integrated circuit (from 1958)[12] and the minicomputer. In particular, not all these firms were able to adapt to the new integrated circuit and to the new trajectory of the microcomputer, initiated in 1965 by DEC's PDP8:

> US established producers were not able to make a successful transition, in spite of the fact that the technological shift in components from transistor to integrated circuit was less radical than the previous shift from vacuum tubes to transistors. This may be due to the fact that demand for minicomputers was radically different from the demand for mainframes. US mainframe producers moved late into minicomputers (or did not move at all), due to a lock-in effect into mainframe technologies, a focus on the well-established demand by large users and a lag in the perception of new technologies and demand. (Malerba and Orsenigo, 1996: 70)

Some of the mainframe producers completely missed this opportunity, just as some would later on miss the PC and microprocessor opportunities (see Box 3). Consequently, the door was open in the 1970s for new entrants: Apple, Compaq, Commodore, Tandy, Olivetti and Sinclair, although not all of these companies were successful in the long term. It was only later on that the alliance of IBM with Intel

[11] In the late 1970s TI and Motorola had more than 70% of the world market in semiconductors, as they were favoured by scale-dependent technology (Chandler, 1997: 94), and were able to provide large funds for quick renewal of their fixed capital. It was only then, and under these circumstances, that it became true that 'the electronics story thus differs from that of the other post World War II high tech industries in that a much smaller number of large companies dominated major markets' (*ibid.*: 97).

[12] Many authors have frequently noted the dramatic decrease in the price of the integrated circuit and this is a critical observation if we are to identify it as a core input. In 1958, its average price was $720, in 1961 $100, and in 1964 $2.55 (Landes, 1969: 518).

Box 3 Missed opportunities

Chester Carlsson created Xerox after Kodak rejected his new copying machine, since its production would imply the creation of a new line of business. Later on, Xerox rejected Steve Jobs's offer of a new computer, for the very same reason. So did IBM and Hewlett–Packard, and Apple was created.

In 1957, Robert Noyce quit Schockley Semiconductors to become part of Fairchild Semiconductors, a pioneer in the industry and in Silicon Valley. Later on, a dispute over managerial rules and hierarchical privileges led him to leave and to form Intel.

In 1986, IBM rejected an offer by Bill Gates to buy 10% of Microsoft, a small firm with 30 employees. The net value of that share in 1997 was around $3bn.

This suggests that a concrete sociological study of the diversity of agents and not only simple assumptions about the level of information may play a role in the explanation of technological development (Audretsch, 1997: 68).

(standardization plus modularity) and the generalization of a reference in operating systems as well as the extensive production of software allowing for a widespread panoply of applications (Microsoft) established high barriers to entry. But again, the internet and networked PCs favoured new opportunities, as the creation of new operating systems (Linux) and mobile computing may also do.

To further illustrate the complexity of the phenomena involved in the transition, recent complementary evidence based on the SPRU patent database draws attention to the less conspicuous process of change that occurs *inside* corporations. It has been acknowledged for some time now that large companies are generally multi-technological (Granstrand and Sjölander, 1990; Patel and Pavitt, 1998). However, beneath a stable diversified technological portfolio, an intensive process of accumulation of ICT competencies seems to have been taking place since the late 1980s. In other words, technological diversification has become biased towards ICT. New evidence suggests that large companies in nearly all industries are increasingly changing their technological portfolios to include semiconductors, computers, telecommunications, and image and sound patent classes (Mendonça, 2000). Therefore, by the 1990s, cutting-edge ICT capabilities are no longer exclusive of ICT sectors. Moreover, technological diversification is uneven not only among technologies, but also across sectors. The patent shows the increasing importance of ICT for the motor vehicles and parts sector, as well as for the aerospace, photography and photocopy, machinery, metals and materials sectors. Work by Hagedoorn and colleagues (2000) suggests that networking capabilities might have been crucial in absorbing the new ICT, since companies in the chemical, mechanical, aerospace and automotive businesses concentrated their technological alliances in the semiconductor, computing and telecommunications technologies. While this is so, pharmaceutics and biotechnologies are becoming more and more important in the knowledge mix of the food, beverage and tobacco, and the chemicals and pharmaceuticals industries.

The development of corporate capabilities in the key technologies of the emerging techno-economic paradigm is therefore widespread and a link can be established between the new technological long wave and the trend towards the formation of multi-technology corporations. Evidence put forward by Fai and von Tunzelmann (2001) also points in this direction. Using Reading University's patent database, they found a preponderance of technological scope (capability diversification) over technological scale (capability concentration) in the last quarter of the 20th century, a time when companies are also believed to have simultaneously refocused their core businesses. This observation fits in with Simonetti's (1996: 192) claim that the frenetic takeover activity in the market for corporate control and the increasing diversification into service activities, which were the two major causes of companies exiting *Fortune*'s top 300 list between 1963 and 1987, is evidence of the organizational instability that marks the transition between techno-economic paradigms.[13]

So, why did so many new companies enter the top 200 list in spite of the apparent ability of established large firms to assimilate the radically new ICTs? The information needed to answer this question must surely be qualitative in nature. This sort of evidence does not enter the limited scope of the current paper, but it remains an important task for further research. The question necessarily invites a discussion of non-technological competencies, for which we can again find some guidance in the empirical work undertaken in innovation studies. Indeed, the organizational capabilities required for the implementation strategies in the new ICT markets were quite different from those that big firms nurture in the context of their other markets. In fact, ICT companies,[14] while investing across a diverse range of information and communication competencies, have been found to be focusing their marketing and distribution strengths on fewer businesses (see Gambardella and Torrisi, 1998).

According to the data, profits rose whilst the profit rate continued to decline after its historical peak of 1956–1965 in the United States (Duménil and Lévy, 1993). Most private businesses went through a structural process of readjustment in the 1970s and, in 1997, in spite of some years of upturn, the aggregate profit rate had not yet recovered half of its value in 1948. As the figures show, the experience of ICT-related industries contrasted with sectors affected by the downswing of the fourth long wave, as consumers and industrial customers placed greater and greater value on services provided by ICT applications. This mismatch with the rest of the economy helps to explain the seductive attraction of the 'new economy' bubble, which appeared to offer quite extraordinary profits to the most fortunate investors. During 'bubble' expansion periods, it may sometimes seem that the law of gravity is broken, but sooner or later tensions

[13]An article in *The Financial Times* (Waters, 2001: 11) makes this observation as clearly as possible: 'Big companies in all industries routinely fail to exploit the new markets emerging under their noses. Nowhere, though, have the mistakes been as glaring as in computing, thanks to the frequent technological shifts that have opened the door to successive generations of newcomers.'

[14]This paper considers the largest 32 US and European companies in the office equipment, computers, telecommunications and consumer electronics industries.

around the new regime of regulation intensify and develop into open conflicts such as the Microsoft anti-trust case, the Seattle World Trade Organization negotiations, and the huge takeover battles in the ICT industries.

5.3 Epilogue: a motion picture

To sum up and answer the first of our questions in the introductory section, we believe that we have found evidence of structural change among US manufacturing giants. Patterns of company turnover and size mobility show that there is uneven change over time and across sectors. We have confirmed long-term differentials in the profitability and sales performance of various sectors, which is a stylized fact anticipated by evolutionary economics, considering the heterogeneity of agents.

As expected by the neo-Schumpeterian long-wave hypothesis, we found the sectors associated with declining technological paradigms to be losing importance and new sectors to be emerging, as measured by total assets in the population. We found that the direction of new entries into the exclusive top to be attracted by the office equipment sector. Office equipment evolved from punch-card mechanical devices to valve technology and the microchip and multipurpose software.

The disturbance of established industrial patterns reminds us that economic life is as much about capital accumulation and learning as it is about scrapping and forgetting. During the 20th century, the companies at the top changed in terms of their core businesses, entered new sectors, some merged, others were absorbed and the survivors kept changing their technological capabilities.

The third of our initial questions concerns the corporate implications of the process of techno-economic change. To the extent that our results allow us to assess the existence of a link between technological and organizational change, through our data concerning industries or principal product classifications, we find that all point to creative destruction happening also at an organizational level. We might put forward the proposition that technologies and organizations have co-evolved, even though we cannot strictly prove it. The rise and consolidation of new core technologies was associated with the replacement of the established top 200 companies with new ones involved in the new ICT-related business and with the acceleration of internal change in those companies that remained on the list. With time, the ability to manage information became critical for the sustained development of companies in all sectors. But, although the technologies of the rising ICT paradigm define a changing landscape, the exact outcomes of that process are not rigorously predictable. This certainly provides interesting raw material for industrial history in the future.

6. Conclusions

In the context of our discussion of a hypothesis (*long waves in the history of capitalist development*), we attempted to illustrate an approach (*appreciative theorizing*) and to disclose fresh empirical results from quantitative data (*Fortune magazine directories,*

which can be used to extend Chandler's information to the second half of the twentieth century). Four main conclusions emerge from this research.

Firstly, change and not stability is the permanent feature defining these very important institutions of capitalism. The continuity thesis is challenged since evidence from the highly oligopolistic markets and from firms protected by enormously high barriers to entry suggests that change and not stasis dominated their trajectories. A high percentage of the larger firms emerged before the divide between the third and fourth long wave and disappeared afterwards, or were created only after that moment. Turbulence, or movements of simultaneous entry and exit, seems not to be homogeneously spread through time. This is evidence pointing towards the creative destruction of business organizations. Sweeping technological change is one of the few factors capable of shaking up highly concentrated corporate structures.

Secondly, the emergence of new industries based on the changes associated with the diffusion of ICT was the driving force either for the creation of new firms or for the access of old but transformed firms to the top list. Furthermore, the older surviving giants are, in general, those that were able to change and to explore new processes of production, new knowledge and new markets. Therefore, while technological change represents a force contributing to the exit of established firms, their social and organizational resources, although difficult to put into operation in changing technological landscape, seem to be a countervailing factor contributing to the odds of survival and adaptation.

Thirdly, the dynamics of entry and the growth of the office equipment sector was driven by the accumulation of profits, and this is related to technological competencies and organizational capabilities. This dynamics was associated in particular with the motive and carrier branches of the fourth long wave, as well as those prefiguring the shape of the next long wave. Indeed, one striking finding in the data is the unusually high rate of entry since 1983 in ICT-related sectors when compared with other industries throughout the century.

Fourthly, we may suggest a rationale for the NASDAQ crisis and the turbulence in the new technologies markets and stocks at the beginning of the first decade of the 21st century: although these markets and stocks were able to concentrate higher profits than the rest of industry during the decay of the two last decades, and thus were able to attract large amounts of capital looking for profitable investment, there is a diminishing marginal ability to keep pace with this higher profit rate given the socio-institutional mismatch of the new techno-economic paradigm (Freeman and Louçã, 2001). Consequently, the speculative boom is now ending and it is time to renegotiate and reorganize the social and institutional conditions for a shift in the techno-economic paradigm.

Turbulence is the future, just as it is the past of these giant firms: after all, they all live in a world of permanent, but not so smooth, change. In the real long run of historical time, the stationary state so revered by traditional economists reveals its true colours: economies, firms and social actors are in fact part of a sweeping process of steady change. And this is both the condition and the opportunity for progress: unlike Dante,

who at the entrance to hell read the terrible dictum, *dopo questa posta lasciate ogni speranza*, we know that beyond the entrance to reality, change is the only hope. Principles of change must also serve in economics.

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Appendix

Classification of industries

Food, beverages and tobacco	SIC 20, 21
Textiles, apparel and footwear	SIC 22, 23
Forest and paper products	SIC 24, 24, 26
Printing and publishing	SIC 27
Chemicals, pharmaceuticals and cosmetics	SIC 28
Oil, plastic and rubber	SIC 29, 30
Building materials (glass, concrete, abrasives, gypsum)	SIC 32
Metal products	SIC 33, 34
Transportation equipment (shipbuilding, railroad equipment)	SIC 37
Electrical and electronic equipment	SIC 36, 35
Motor vehicles and parts	SIC 37
Aerospace	SIC 37
Scientific, measuring, control and photographic equipment	SIC 38
Industrial and farm equipment	SIC 35
Office equipment	SIC 35
Miscellaneous (musical instruments, toys, sporting goods)	SIC 39