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# INDUSTRIAL REVOLUTIONS AND THE EVOLUTION OF THE FIRM'S ORGANIZATION: AN HISTORICAL PERSPECTIVE \*

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# INTRODUCTION

Capitalism brought the capitalist firm into being, and the first manifestation of this form was the factory. Since its emergence, historical events have shown that crucial shifts in firm organization coincide with industrial revolutions. Even the factory itself was the result of the British Industrial Revolution (BIR), and later, following the Second Industrial Revolution (SIR) the large modern business enterprise appeared by the 1920s. This firm organization is called a multidivisional form (M-form). In today's ICT revolution <sup>1</sup> we are witnessing another important shift in firm organization: large vertically integrated firms are becoming flatter, decentralized and organized in semi-autonomous project-based teams. In the literature this novel firm organization is mostly referred to as a project-based firm <sup>2</sup> (see Whitley, 2006). What drives these significant shifts in firms' organization? Do these transformations challenge the essence of the firm? Clearly, these questions concern the issue of the evolution of a firm; and are questions which are not addressed in the post-Coasean theories of the firm (e.g., Williamson, 1985).

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<sup>1.</sup> It is widely accepted that the role the new ICTs play can be paralleled with that of the inventions of the BIR and SIR, and thus it has to be considered a third industrial revolution (Freeman, Louça, 2001; Mokyr, 2002; Chandler, 2006).

<sup>2.</sup> Note that there are also other labels used in the literature as regards this type of firm organization due, to a significant extent, to the diversity of the forms themselves. An interesting thing is that the M-form and the factory were more homogeneous when they first emerged.

Nevertheless, there is no doubt that the analysis of the evolution of the firm can contribute to a better understanding of a firm.

In a broad context the aim of this paper is – by taking a historical perspective – to analyze and explain the evolution of firm's organization, and identify the driving force in the shifts of that organization. More precisely, this historical analysis is intended to serve as a basis to draw conclusions concerning the respect(s) in which particular firm organizations differ from one other. In this way, the theory of the firm perspective and the economic history perspective will complement each other, as in Chandler (1992), but my perspective will be wider than his, including all firm organizations, not only the M-form.

The historical analysis of the evolution of the firm will be constructed in the framework of the co-evolution of social and physical technology (Nelson, Sampat, 2001; Nelson, 2002). The argument will be that the evolution of the firm must be seen as part of this co-evolutionary process which, as historical events show, has largely been driven by significant changes in physical technology, i.e., macro-inventions in Mokyr's (1990) terms. From the viewpoint of the theory of the firm the conclusion will be that the above three firm organizations must be considered as mutants, and the major difference between them is related to the shift in the mix of low and high-powered incentives (Williamson, 1985) used within a particular mutant-firm.

The paper is organized as follows. Section 1 shows the framework of the historical analysis. Sections 2, 3 and 4 analyze the rise of the factory, the M-form and the project-based firm, respectively. Section 6 presents my conclusions.

#### THE FRAMEWORK OF THE HISTORICAL ANALYSIS

The context in which I propose to explain the major shifts in firm organization is the co-evolution of social and physical technology (Nelson, Sampat, 2001; Nelson, 2002). Social technology is a broader concept than that of institutions, and it encompasses ways of organizing transactions both across and within organizations. That is, both behaviours associated with getting things done within organizations, and behaviours associated with market activity are included. To put it clearly, social technology involves first, the institutional environment, usually defined as determining the rules of the game (North, 1990), second, organizations (governance structures in terms of Williamson, 1985), and third, deeply embedded norms and rules (informal institutions). Physical technology is something that is traditionally understood as technology by scholars of economic growth, that is, production technology. According to Nelson and Sampat (2001) and Nelson (2002) social and physical technologies are evolving together, that is, the two interact causally with one another.

In this co-evolutionary process there are feedback loops between the social and physical technology, meaning that the interplay between them works in both directions. However, the major problem here is that there is a circularity of causation: changes in physical technology cause changes in social technology which, in their turn, entail further changes in physical technology. This problem becomes more serious if we take into account the fact that some changes in physical technology, in the spirit of Pelikan (2003), can be absorbed by social technology <sup>3</sup>. On the other hand, there is no doubt that it is not *all* but only certain change in social technology that affects physical technology. Accordingly, the crucial question in an understanding of the co-evolution is, which elements of the social technology (if not all) and which kinds of change in physical technology affect each other, and in what way. Moreover, the most important question is what drives the whole co-evolutionary process?

To overcome this problem, in the field of physical technology I argue that we should rely on the distinction, proposed by Mokyr (1990), between macro-inventions and micro-inventions. This allows us to have a more comprehensive view of the co-evolution of social and physical technology. Mokyr (1990) proposes to call major technological advances macro-inventions, which essentially create new techniques and tend to be abrupt and discontinuous. They represent a break compared to the previous techniques. Macro-inventions are usually followed by a large number of micro-inventions that improve and refine them or make them workable without changing the context of the macro-inventions. Micro-inventions result, for example, in better quality or cost reduction.

The reason for differentiating between macro- and micro-inventions is that they are driven by different forces. Since micro-inventions are the results of a conscious search for improvements in macro-inventions, they can be conceptualized as driven by economic forces of demand and supply (Mokyr, 1990). However, "macro-inventions ... do not seem to obey obvious laws, do not necessarily respond to incentives, and defy most attempts to relate them to exogenous variables. Many of them have resulted from strokes

<sup>3.</sup> To be precise, Pelikan (2003) argues that there is a certain variety of (physical) technological changes that the prevailing institutions (social technology) can absorb without themselves having to change. He calls that institutions' innovation absorptivity.

of genius, luck, or serendipity" (Mokyr, 1990, p. 13). Usually macro-inventions emerge in clusters in which one macro-invention can stimulate others and they are followed by numerous micro-inventions, creating an industrial revolution <sup>4</sup>.

What is important for my concern is the fact that micro- and macroinventions differ from one other in terms of the kind of changes they induce in social technology. Since, by definition, micro-inventions do not exceed the social technology's innovation absorptivity, they will not provoke major changes in social technology; instead, they may lead to a fine-tuning of various elements of social technology. As opposed to that, macro-inventions cannot be fully absorbed by the prevailing social technology; sooner or later they bring about radically new social technology which has not existed before.

An important feature of macro-inventions is that they are to a large extent exogenous in an economic system. This means that radical technological breakthroughs cannot be fully explained by forces of the social-economic system, instead being subject to an evolutionary process chance; luck also plays a role in their emergence. However, being partly exogenous, macro-inventions have the capacity to start and keep moving the whole coevolutionary process, i.e., they are the driving force in the co-evolution of physical and social technology.

In what follows through a historical analysis I will show that we should consider the evolution of the firm as part of the co-evolutionary process, and for this reason I will focus on those aspects of this co-evolutionary process that concern the evolution of firm organization.

## THE FIRST PHASE IN THE EVOLUTION OF THE FIRM: THE RISE OF THE FACTORY

The macro-inventions of the BIR induced significant changes in various elements of social technology, more importantly in the way the work was organized, which led to the rise and spread of the factory. The factory itself was the major novelty in the BIR which had an enormous effect on the development of economies as a whole. But what was a factory? This question is crucial because the attributes of the factory must be clearly distinguished from

<sup>4.</sup> It must be noted that the concept of macro-inventions can be paralleled with that of radical innovations, while the concept of micro-inventions with that of incremental or minor innovations (see Freeman, 1994). In addition, macro-inventions are general purpose technologies, as is also proposed by Lipsey et al. (2005). Thus, instead of the terms "macro-inventions" and "micro-inventions" other terms could also be used.

its *distinctive* attribute. Of course, the factory shares many characteristics with other kinds of organization, but being interested in its uniqueness we have to determine that feature that exclusively characterizes it (as opposed to previous organizational forms). This requires an analysis of the emergence of the factory from the viewpoint of the theory of the firm.

The factory replaced the putting-out system that was based on the "family firm" craft-shop. The craft-shop was run by a master craftsman with a couple of journeymen, apprentices and family helpers. Under the puttingout system the merchant-entrepreneur owned the raw material, the goods in process, the equipment and tools, and outsourced the work at piece rates to workers who usually worked at home. The factory was a new organizational form: it was a firm, while the putting-out system was a market-like organization based on market contracts. And as argued in the theory of the firm literature (e.g., Foss, 2002; Kapás, 2004) the distinctive feature of the firm is the predominance of authority among the coordinating devices used within the given organizational form <sup>5</sup>. Accordingly, it is not large-scale production as such that was the essence of the factory, but rather firm-like monitoring <sup>6</sup>.

Many argue (e.g., Landes, 1969; Mokyr, 2002; Leijonhufvud, 1986) that the rise of the factory was primarily or at least largely driven by the new technology. However, when analyzing this process in the co-evolutionary framework it becomes clear that this does not imply that technology should be seen as the unique factor inducing the rise of the factory. Instead, what I intend to argue is that the new technology has been only one among several factors, but it has been the determining one <sup>7</sup>. Clearly, the period 1760-1850, known as the BIR had an enormous long-run impact on Western Europe. The essence of the BIR was technical. The technological advances occurred mostly in the following four areas: energy (water power, steam engine), metallurgy (iron making), cotton (cotton spinning, mechanical weaving) and diverse industries and services (canals and road building). The main technological features were a new infrastructure (railways), a new source of power (steam engine), new machine tools (Freeman, Louça, 2001).

Let me now analyze the co-evolution of physical and social technology during this period. Such an analysis must start with analyzing those changes – partly arising from outside the economy – which were capable of setting in

<sup>5.</sup> This argument is based upon the view that the firm is a complex of coordinating devices (Ménard, 1994).

<sup>6.</sup> To underpin this claim note that many entrepreneurs in the putting-out system worked with a large number of masters (Pollard, 1965), and on the other hand, there were plants working only on small scale (Landes, 1969).

<sup>7.</sup> Jones (1987), for instance, clearly shows that technological factors were primarily responsible for the adoption of the factory system in the silk industry.

motion the co-evolutionary process. As argued above, it is macro-inventions that are subject to the greatest extent to exogenous factors. To a non-negligible extent, during the BIR, these were due to talented inventors whose activities cannot be regarded as consequences only of the prevailing social and economic factors, that is, the inventions were the results of individual genius, rather than the outcome of a conscious social process (Freeman and Louça, 2001). This is not to say that endogenous factors, such as institutions, could not play a role; quite the contrary. The uniqueness of Britain was precisely its extremely favourable institutional background for technological advances. In fact, there was a congruence of favorable developments in all subsystems of the society and their positive mutual interconnection. So, macro-inventions could not have come partly "out of the blue" if the institutional background had not supported such a process. Mokyr (2008) sheds light particularly on the overwhelming role of informal institutions, where Britain's configuration was unique: most business was conducted on informal codes and relied on reputation. These norms involved a variety of devices associated with "gentlemanly" behaviour. This behaviour made it possible to overcome the kind of free riding and opportunistic behavior that seem to require coercion by formal state institutions.

Besides informal institutions, formal institutions were also favorable for inventors. Amongst them the Parliament seems to have had crucial importance in inducing favourable changes both in social and physical technology (Mokyr, 2008). Due to the control of the Parliament, the state was not predatory. The importance of this fact is that profits generated for entrepreneurs through technological breakthroughs were not expropriated by the state, which is also somewhat related to the issue of government regulation. The British government was not interventionalist, unlike many other governments in the Continent. This behaviour of the government rested most probably on the notion of free trade, an idea which was introduced by Adam Smith's book: profit-seeking activities were seen as promoting social welfare.

Besides secure property rights, the rule of law and the patent system, Britain created alternative organizations that encouraged innovation and the dissemination of knowledge. Notable examples are the Royal Society of Arts, the Royal Institution and Mechanics Institute. In addition, in Britain technical training through master-apprentice relationships was at a relatively high level, favouring learning by doing, and creating a favourable climate towards inventions and experimentations. So, macro-inventions arose partly due to the above institutions, and once they occurred, they were intertwined with micro-inventions, and they affected social technology as well. The most significant effect the macro-inventions had was on the way production was organized and labour was divided within production units: the capitalist firm, i.e., the factory was born to carry out production instead of households. Saying that production broke away from the household is equal to saying that an individual mode of production was replaced by a collectively organized mode, i.e., team production. Team production involves an increased specialization of labour and standardization of products (Langlois, 1999), and it requires the coordination of activities in terms of time-phasing of the inputs of individual workers. The efforts of individual workers become complementary inputs, which implies that marginal products are costly to measure, creating a free rider problem. As Alchian and Demsetz (1972) argue, the solution to this problem is to appoint a monitor (the capitalist) who is given the rights to the residual income, which gives him the incentives to perform the efficient amount of monitoring.

But why did the new techniques require team production? On the one hand, the new techniques changed the optimal scale of production (Leijonhufvud, 1986): some equipment could not be used equally efficiently in small craft-shops and in large plants (e.g., chemicals, iron making). In parallel, the new machinery incurred high fixed costs, which were impossible for individual craftsmen to finance. On the other hand, and even more importantly, the new machinery could not have been used by individual artisans, simply because of the lack of appropriate technical knowledge and/or lack of strength. As made clear by Mokyr (2002) the new machinery required a higher level of competence, and led to a better division of labour. After 1760 many of the industries increasingly required a level of knowledge and a set of operating procedures that were beyond the capacity of the individual household. Factories were the only possibilities to hire experts like engineers, mechanics and chemists. An advantage of the factory was that inside the factory individuals knew and could trust each other, and this turned out to be an efficient way of sharing knowledge: factories served as repository units for technical knowledge and reduced access costs to knowledge for individual workers.

Note however that the team production argument à *la* Alchian and Demsetz (1972) comes to play only in the second place: the fact that the labour of individual workers became a complementary input, implying that marginal products were costly to measure and consequently a monitor was appointed, was the result of the new technology and mechanization. The most important aspects of the factory are as follows: (1) the size of the workforce in one and the same workplace (Leijonhufvud, 1986), (2) the new machinery, (3) team production. Factories operated under individual proprietorship or partnership, joint-stock companies appeared only in public utilities (canals, water supply, railroads) (Landes, 1960), which implies that the owner-capitalist in general monitored the operation of the whole factory.

The fact that the large scale plant made the workers specialize, together with increasing complexity of the whole production process, made coordination, monitoring and supervision extremely important within factories. From the viewpoint of the theory of the firm the factory may be seen as the type of firm organization which is the closest to an abstract view of the firm as a planned institution deliberately created to coordinate the division of labour. This is reflected in how work was coordinated within factories. First of all, factories had a simple bottom-line organizational structure with highly centralized decision-making and responsibility. The factory owner regulated almost everything within the factory, he administered discipline, organized the flow of goods between processes and workers, he exercised great control over quality (Cohen, 1981). Briefly, the capitalist became the supervisor who introduced strict supervision and rigid discipline<sup>8</sup>. As Pollard (1963) explains the capitalist-owner used a wide range of incentives to make the workers behave in the right way and work efficiently<sup>9</sup>.

To summarize the above, the nature of monitoring changed significantly in the factory (Langlois, 1999): instead of monitoring the output as in the putting-out system, the capitalist monitored the production process itself, which meant that a market-like monitoring was replaced by a firm-like monitoring. The latter involved a new kind of authority relationship between the capitalist and the workers (see Simon, 1951). The factory spread gradually over a long transition period, but the spread was reinforced by the new wave of micro-inventions in the second phase of the BIR. After the macroinventions of the period 1760-1820, the 1820s witnessed another wave of inventions, which although not as spectacular and path-breaking as the inventions of the previous period, were nevertheless highly important. These were micro-inventions: for instance improvements in high-pressure engine design, Stephenson's locomotive (Mokyr, 2002). Such inventions were to a large extent induced by the factory itself. In this sense the spread of the factory became self-enforcing: the factory offered a favourable climate for further technical improvements (micro-inventions), which in turn, stimulated the fine-tuning of the organization of the work within the factory.

As shown above, the factory itself was a particular social technology that arose largely as a response to significant changes in physical technology (macro-inventions), while, in a second phase, micro-inventions also contributed to its spread.

<sup>8.</sup> For further details of the factory discipline see McKendrick (1961).

<sup>9.</sup> Among these incentives we find various negative ones such as threat of dismissal, fines and deductions, corporal punishments as well as positive ones such as premium, promotion, kindness (Pollard, 1963).

## THE SECOND PHASE IN THE EVOLUTION OF THE FIRM: THE RISE OF THE M-FORM

Macro-inventions of the BIR such as the railway, the telegraph and iron making experienced continuous improvement, which, in turn, led to a new industrial revolution. So, unlike the BIR, where initially macro-inventions provoked changes in social technology, the SIR started with micro-inventions in the railway and the telegraph which had enormous impact on social technology by bringing about important innovations. Among these the rise of a new firm organization, namely the multidivisional form (M-form), was the most significant. Nevertheless, micro-inventions gave only the first impetus on the road towards the rise of a new firm organization, and late-comer macro-inventions (e.g., the motor vehicle) reinforced this process.

Thus the technological paradigm in which the factory was the dominant production structure was challenged in the 1860s, which brought about gradual changes in firm organization, culminating in the rise of the multiunit firm<sup>10</sup> by the 1920s. I will show below – based on Chandler's (1962, 1977, 1990) brilliant account of how the modern business enterprise has emerged – that the coming into being of the M-form as new social technology occurred in several phases in which physical and social technologies coevolved. As mentioned above, the revolution in transportation and communication gave the whole process the initial boost: the railway had the first significant impact on U.S. business firms. As a result of various micro-inventions railways became faster, safer and more comfortable. The steam locomotive provided fast, regular, safe and reliable transportation and also lowered the unit cost of moving goods, which was essential to high-volume production and distribution (Chandler, 1977). This had an impact on social technology, especially in three areas: (1) it brought about the first formal administrative structure with professional managers inside the rail companies, (2) it created a need for novel institutions such as the modern investment bank, accounting and statistical innovations, limited liability, etc., and (3) it gave rise to mass distribution and mass production.

<sup>10.</sup> The major characteristics of the M-form from are as follows (Chandler, 1990; Rajan, Zingales, 2000): It is (1) large enough to exploit potential economies of scale and scope in production and distribution, (2) physically capital-intensive, (3) integrated both forward and backward, (4) oligopolistic, and (5) run by professional managers. In such an enterprise each division could act as an independent business enterprise and deal with a conceptually different business, organized mainly along product, brand or geographical lines. The divisions are entrusted with making day-to-day operating decisions, while the corporate office is concerned with strategic decisions and can use incentives to favour divisions' operating behaviour consistent with its objectives (Chandler, 1962).

As far as the first impact is concerned, the complexity of the railways' operations required professional managers who subdivided their operations into smaller groups and then appointed middle-managers to supervise and monitor the different functional activities: the movements of trains, the handling of traffic, the maintenance of motive power, equipment, and accounting (Chandler, 1990). To operate these activities railway managers devised a line-and-staff system; both departments and central offices were built up.

Besides the transformation that took place inside the companies, new institutions were also needed. The railway was the first modern high-fixedcost business which required novel forms of financing (Chandler, 1990). The capital requirement was very high, which led to the concentration of the national money market in New York City and the formation of exchanges. Besides modern financial institutions, because of the volume of transactions, accounting became more complex and required new standards and new techniques. Another new need was created for well-educated managers which, some decades later, brought the modern business school into being.

The third impact of the railway and telegraph was the development of mass distribution (Chandler, 1977) because they permitted a dramatic decrease in transportation costs. This expanded the market in a way never seen before. There appeared the modern mass marketer (e.g., mass retailer, chain store) who purchased directly from the manufacturers and sold directly to the retailers and final consumers. The new method of transportation made it possible to handle large flows of raw materials into and finished products out of the factory. The realization of this required the invention of new machinery and processes (Chandler, 1977). These were important micro-inventions. However, these micro-inventions coincided fortunately but accidentally with a new wave of macro-inventions, forming the industrial revolution, which was even far more wide-ranging than the BIR. Macro-inventions of the SIR were electricity and the motor vehicle, and shortly afterwards the aeroplane, although the last of these was not a serious commercial proposition before the 1920s. Chemicals and steel were two key products while electricity, oil and the internal combustion engine were the new energy sources. By the 1880s new industries such as electrical power generation, chemistry, shipbuilding, metallurgy, heavy engineering, large building construction, food canning and armaments emerged. In the second phase automobiles and refineries became key industries.

The new technology went hand in hand with the emergence of mass production. Mass production meant exploiting economies of scale and scope made possible by the new technology, which lowered production costs and increased productivity, while requiring at the same time heavy investment in production facilities large enough to exploit these potential economies (Chandler, 1990). It called for further organizational innovations, i.e., new ways in which the movements and activities of workers and managers were coordinated and controlled (Chandler, 1977), while it reduced the number of workers required to produce a specific unit of output. However, production cost savings of sufficient scale and scope could only be realized by incurring the increasing transaction costs necessary to run large firms (North, Wallis, 1994): building up a hierarchy was the only way to ensure lower production costs.

The final phase in the emergence of the M-form consisted of the integration of the process of mass production with mass distribution within a single firm. The rationale for this was not only that a manufacturing firm no longer found it safe to rely on outside wholesalers or commission agents, because the interests of these agents differed from those of the manufacturers (Chandler, 1990); even more importantly, the divergence of interests incurred higher transaction costs. Another important source of higher transaction costs was a new asymmetric information problem the firms found themselves facing: as products became more sophisticated, consumers became less able to identify the quality of the products. One important solution to the "lemons" problem was for firms to use advertising and brand-names as a commitment not to cheat (Kim, 2001), i.e., the integration of distribution.

Some enterprises went further: besides handling their own marketing and manufacturing, they took over the production of their raw materials, which expanded vertical integration. An advantage of the internalizing of these activities was a decrease in the total costs, i.e., in the sum of transaction and production costs (North and Wallis, 1994)<sup>11</sup>. As demonstrated above, due to particular historical facts the way physical technology affected social technology manifests certain particular characteristics which differ from those identified with the BIR. The most significant differences lie, on the one hand, in the fact that the rise of the new firm organization (M-form) appeared in several well identifiable phases (see Chandler, 2006) meaning that feedback mechanisms became more important. On the other hand, the first significant changes in firm organization resulted from micro-inventions in railways and the telegraph – unlike in the case of the factory – that were improvements in macro-inventions of the previous period. Macro-inventions came only later, but they provoked further changes in firm organization. Another important feature of the SIR was that it brought R&D labs and research departments into being, meaning that institutionalized research

<sup>11.</sup> Note that Chandler (1977, 1990) was concerned only with the production costs.

started to emerge within both firms and government sponsored laboratories <sup>12</sup>.

The effect of the M-form on institutions was also strong: many new formal institutions were necessary. In this respect the SIR differed from the BIR, where this kind of effect hardly existed. First of all, since there was a strong tendency towards cartelization, vertical integration with raw material suppliers required a new set of rules, including antitrust law. Second, following massive private and public investments and the development of the national money market and stock exchange new regulatory laws were required for these activities as well. Third, as already argued, the coming into being of the M-form gave birth to professional management, which in turn depended on, and at the same time stimulated, the educational system. Giant firms were run by professional managers and used complex administrative structures, which provided a demand for managers. Accordingly, the birth of business schools was an adequate response. Furthermore, even the "style" of managing had also changed: scientific management (Taylorism) was based on the professionalization and specialization of the various functions of management and in some cases also design and development of personnel.

To conclude, the M-form must be seen as mutant *vis-à-vis* the factory because several new features appeared: delegation, divisions with responsibility, scientific management. In fact, due to the above changes, the capitalist firm as such had been improved in many respects compared with the factory.

#### THE THIRD PHASE IN THE EVOLUTION OF THE FIRM: THE EMERGENCE OF THE PROJECT-BASED FIRM

In today's ICT revolution the M-form that has dominated since the 1960s appears to be losing its dominance, and the project-based firm is gradually emerging. The macro-inventions which led to the ICT revolution were the

<sup>12.</sup> This also implied that macro-inventions became less significant in initiating an industrial revolution but remained crucial in maintaining the development of co-evolution. This increasing importance of micro-inventions was also recognized by Schumpeter (1942) when he talked about the "mechanization" of economic progress by big firms. In fact, what the "early" and the "late" Schumpeter emphasized concerning technological advances is in line with Mokyr's macro- and micro-inventions. The "early" Schumpeter (1934) highlighted the exogenous character of innovations, while the "late" (Schumpeter, 1942) emphasized the endogenous scientific activities carried out by large firms. Clearly, the former refer to macro-inventions, while the latter to micro-inventions.

computer and the semiconductor (Mokyr, 2002). Although we do not have the historical experience of the ICT revolution which we have of the BIR and SIR, which makes it difficult to qualify it, one can argue that just as macro-inventions of the past were capable of inducing – micro-inventions and changes in social technology, today's ICT revolution is having the same effects. On the one hand, new industries are developing, such as internet technology, the information industry and biotechnology, and, on the other hand, traditional industries are changing in character. Moreover, the new information technology induces fundamental changes in production technology by requiring new machinery, new materials and new inputs. Of course, these new physical technologies cannot work well with the old social technologies: fundamental changes are needed inside the firm as well as in other elements of the social technology.

Among the changes in social technology the extension and globalization of markets are the most important: the fall in the cost of information gathering and the reduction in the barriers to trade make markets larger and support more competition. Furthermore, new institutions are emerging, for instance in financial markets <sup>13</sup>. The "vanishing hand" of the market (Langlois, 2003) characterizes today's economy in which the market as coordinating mechanism seems to have a comparative advantage over hierarchy, accordingly networking is becoming more advantageous (Powell, 1990). These institutional changes together with the requirements of the new information technologies as regards the organization of the firm affect how work is coordinated within firms, leading to the emergence to a new firm organization. The effects, as shown below, are numerous.

The ICT revolution has significantly changed the character of work: knowledge has become the crucial input, which forces the efficient utilization of the "knowledge of the particular circumstances of time and space" (Hayek, 1945, p. 521). This requires new organizational forms that rely more on teams and projects, and use more flexible methods. As a consequence, the managers exercise guidance, manage conflict situations and enable communication among the teams rather than directly commanding and controlling them (Child and McGrath, 2001). On the other hand, what is becoming crucial is the ability to exploit knowledge; this requires prior knowledge, that is, absorptive capacity (Cohen and Levinthal, 1990) to accumulate and utilize new knowledge. In this way, the absorptive capacity itself must be seen as a valuable intangible asset that can lead to an accumulation of tacit competencies serving as a basis for core competencies (Teece et al., 1994).

<sup>13.</sup> For an overview of the new international financial institutions see Buiter and Lankes (2003).

Today's firms are increasingly focusing on core competencies, or more precisely on core intellectual and service competencies, which also implies that they retain only those activities in which they are best-in-class; activities that cannot be preformed at near best-in-world levels should be considered for outsourcing. This strategy very often leads to firms that are small in traditional terms, but huge in terms of value added; in Quinn's (1992) terms these are intelligent enterprises. While in the past workers have usually been employees, the ICT revolution requires a mix of employee and contractor status. Traditional employment is disappearing in sectors using ICT technology intensively (Bollen, Ramioul, 2007). Workers are becoming "experts" in the new economy; tasks are fuzzily defined, favouring individual entrepreneurship.

Furthermore, the ICT revolution favours modular products. As argued by Sanchez and Mahoney (1996) product modularity requires modular organization (see Langlois, 2002), i.e., firms with project-oriented teams. This firm organization is built on self-organizing autonomous teams which are organized cross-functionally around a well-defined task, observable output or project (Zenger, 2002), comprising a mix of individuals with highly specialized competencies. Project-teams behave entrepreneurially, as actors in the market and they are exposed to a large number of powerful incentives.

The sharp decline in communication and information-processing costs, together with the fact that knowledge became less tacit (Cowan, Foray, 1997) has led to the fragmentation of activities. Due to internet technology much work can be carried out in smaller units or even at home, which erodes the traditional boundaries of the firm. Knowledge is becoming a crucial input, which has a significant impact on the power distribution inside the firm. Knowledge workers who control knowledge assets (Tomlinson, 1999) are highly skilled people, who are more difficult to monitor and have more power. Accordingly, centralized coordination becomes less efficient in today's firms.

The above changes lead, as a major consequence, to changes in the character of authority within the project-based firms: a high degree of discretion is granted to lower levels. That is to say, the project-based firm relies more on high-powered incentives compared with the M-form, meaning that it must be seen as a mutant vis-à-vis the M-form <sup>14</sup>. However, just as the factory and the M-form did not arise overnight but rather we witnessed a hybrid system of the old and new existing side by side with slowly changing emphasis, the large, vertically integrated firms will not collapse overnight.

<sup>14.</sup> For an in-depth analysis of the new firm organization, see Kapás (2004).

## CONCLUSIONS

In this paper, following the Chadlerian historical-evolutionary line in the theory of the firm (Chandler, 1992), I have shown that the factory, the M-form and the project-based firm are particular social technologies that evolved as part of the co-evolution of physical and social technology. The factory was the original form of the capitalist firm, whereas the M-form and the project-based firm must be conceived as mutants. The above analysis of the evolution of the firm pointed to the overwhelming role of major technological advances (macro-inventions) in inducing mutations in the firm organization. Thus, there have been two major evolutions in the structure of organizations: the first began at the turn of the 19<sup>th</sup> and 20<sup>th</sup> centuries, while some 15 years ago we entered a second period of organizational change. The significance of the focus on the concept of mutation is precisely the fact that it contributes to a better understanding of the character of differences between particular firm organizations.

The essence of the factory was centralization. As opposed to the puttingout system where product was monitored, here the factory owner monitored the production process itself (Langlois, 1999). This fact together with the fact that the workers were unskilled, required very strict monitoring, which was possible only when a highly centralized hierarchy was in place. Since the new machinery required routinized movements, no discretion in decision-making was given to workers; instead they were given strict directives as to what to do and how to do it. All this suggests that the factory relied heavily on low-powered incentives, which was indeed appropriate for the prevailing technology.

From the rise of the M-form, however, there has been a shift within firms towards the use of more high-powered devices relative to low-powered ones, which continues even more spectacularly in the case of the project-based firm. As noted above, as a result of the new transportation technology the firm became more hierarchical: middle and top managers were appointed to monitor the work process. This does not necessarily imply, though, that the proportion of low-powered incentives relative to high-powered ones would have increased. It is true that, as the number of levels of management increased, the monitoring and coordination of tasks became more crucial. But at the same time more decision-making rights were delegated to lower levels, which, in fact, increased the relative proportion of high-powered incentives. In fact, the essence of the divisional structure lies in decentralizing: division managers are given legitimacy and power, they are rewarded on the basis of division profits, hence some autonomy is given to divisions as regards operating decisions and there is competition for financial resources between divisions, etc. This means using more high-powered incentives within the firm.

The project-based firm represents a continuation of the above trend: the mix of various coordinating devices shifts much more towards encompassing more high-powered incentives. This stems from the fact that new ICT stimulates competition and entrepreneurship in an economy. For a firm to be competitive in such an environment it is crucial to promote entrepreneurship within its boundaries, too. This principle suggests that small independent entrepreneurial units organized around well-defined projects are more effective, which implies the use of more market-like coordinating devices such as rewards on performance, decentralized decision-making systems, competition among teams and unclear role definitions. However, the important thing is that authority relations do not vanish: since the managers exercise the ultimate decision rights (Foss, 2002) they can always overrule subordinates, i.e., despite the penetration of market-like coordinating devices authority remains the primordial coordinating mechanism within each particular firm form (Kapás, 2004). This implies that the difference between mutants of the firm is a matter of degree and not of kind. So, what altered - due to major technological advances - during the evolution of firm organization was the mix of low- and high-powered incentives.

In fact, all three firm organizations must be considered as efficient solutions to the economic problems of their own age. As a result no one of them has a supremacy over the others, meaning that each may have comparative advantage depending on the character of the techno-institutional environment. While the most advantageous form always gains ground <sup>15</sup>, the other, previously existing, forms do not entirely disappear; accordingly the various firm organizations co-exist. To illustrate this, it is clear that the big multidivisional firm has not collapsed and continues to prosper in many industries while the project-based and network-type firms are basically present in knowledge-intensive industries such as the biotechnology and semiconductor industries (see for instance Powell et al., 1996). Besides this there are of course numerous examples of highly centralized hierarchies, which are today's successors of the factory.

One important argument in favour of the co-existence of various firm organizations is that organizations, in the initial stages of their life cycle, display diversity in form, but once they become well established there is a push towards homogenization (DiMaggio, Powell, 1983), that is, a dominant form

<sup>15.</sup> This argument is in accordance with the isomorphism theory of DiMaggio and Powell (1983) who stress that organizations tend to model themselves on similar organizations facing the same environmental conditions.

is reinforced. Another argumentation comes from the metamorphosis view (e.g., Mintzberg, 1983). Mintzberg argues that the adhocracy that can be paralleled with the project-based form is preferred in the early years of an organization's life cycle. However, empirical evidence also suggests (see Foss, 2003 for an example) that organizational metamorphosis is a very general phenomenon that characterizes not only start-ups but mature firms as well.

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