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# Taxonomy of Operations, Costs and Benefits Relevant to the Creation, Existence, Evolution and Growth of Firms

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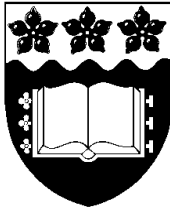
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**Taxonomy of Operations, Costs and Benefits  
Relevant to the Creation, Existence, Evolution and  
Growth of Firms**

Elias Sanidas

WP 01-12

# **TAXONOMY OF OPERATIONS, COSTS AND BENEFITS RELEVANT TO THE CREATION, EXISTENCE, EVOLUTION, AND GROWTH OF FIRMS**

**Elias Sanidas**

## **ABSTRACT**

*Most of the standard economic analyses of the firm utilize only the capital (including the human one) and labor factors, and a term called technology to embrace all the remaining elements. The introduction of the transaction costs (TCs) by Coase (1937) has generated a new stream of complementary theory of the firm as developed mainly by Williamson (1985 etc). Then, a critique on TCs has lead to the recognition of other factors such as internal capabilities, information and know-how, routines, strategies, and so on. However, it seems that there is still a gap in economic theory or management theory as to the exact nature of all types of costs (besides transaction and production costs) involved in the creation, existence, and evolution of firms. According to my findings, all the activities and practices of firms can be split into 5 interdependent groups of processes of operations, namely those of movement, of factors, of contracts, of wisdom, and of strategies. In turn, each one of these processes is related to kinetic, physical, transaction, wisdom, and strategic costs respectively. Then, for each group I assign several essential characteristics that fully describe it. The implications of this paper are also briefly discussed.*

*Key Words: firm operations; transaction, factor, wisdom, strategic, and kinetic costs; growth of firms, benefits, process, creation, existence, evolution, movements, capabilities, and production.*

## **INTRODUCTION**

(For acronyms see also last page)

Much of the standard economic analysis of the firm utilizes only the capital (K) and labor (L) factors, and a term called technology to embrace all the remaining elements. The introduction of the transaction costs (TCs) by Coase (1937) has generated a new stream of complementary theory of the firm as developed mainly by Williamson (1985 etc). Then, a critique on TCs has lead to the recognition of other factors such as internal capabilities, information and know-how, routines, strategies, and so on (see for example the classical work by Penrose, 1959, or some more recent collections of relevant articles edited by either Foss and Knudsen, 1996, or Foss, 1997).

However, it seems that there is still a gap in economic theory or management theory as to the exact nature of all types of costs (besides transaction and production costs) involved

in the creation, existence, and evolution of firms. My endeavor will be, in the following pages, to isolate some fundamental sub-processes within the overall process of production, which can be considered as the atoms of analysis of costs and hence benefits. In other words, once these fundamental sub-processes are determined, all other costs can be easily derived. To carry out my endeavor, I will use relevant examples, which will lead to appropriate conclusions. This will be the object of the second sub-section.

I will review the existing literature in the first sub-section. The other two sub-sections will complement my propositions; thus, I insist a bit further on the creation and existence of firms in the third sub-section, whereas I link the fundamental sub-processes with the major historical production systems in order to see the importance of the former more closely. The purpose of all this analysis is to dig deeper into the process of economic growth by shedding light into its core, namely the firm. With this deeper digging I intend to show that once we know all types of costs and benefits related to all activities and practices of a firm, we would be able to better understand the growth and evolution of firms and hence be able to review and suggest policies for improvement, not only on a firm basis but also on a sector and macro levels.

## **1.1 THE NEED TO BRIDGE THE EXISTING GAP IN ECONOMIC THEORY**

In this sub-section I will review some selected articles to indicate how much we need to extend our analysis beyond the transaction costs theory (TCT). Williamson is one of the main proponents of the TCT; in a relatively recent article (1997) he contrasted the non-TCT with TCT as follows:

*“...Thus, although the theory of the firm-as-production function is a useful construction for examining a wide variety of price and output issues, it is not an all-purpose theory of the firm for purposes of ascertaining firm boundaries (the make-or-buy decision), the nature of the employment relation, the appropriate choice of financial instrument, corporate governance mechanisms, divisionalization and the like...” (p. 2)*

Thus, the firm as a production function, hence as a function of capital, labor, or technology inputs, is not sufficient to explain many other aspects such as governance. In addition, each generic mode of the latter is supported by a distinctive form of contract law, and is influenced by both the institutional environment (political, legal, customs, norms) and the behavioral attributes of individuals (emanating from bounded rationality and opportunism). Consequently, the TCT extends the concept of the firm and its variations into a different dimension.

However, the TCT has been criticized by several scholars. One of the early criticisms was that of the problem of tautology as Williamson himself was also aware of (Ibid, p. 13), according to which almost anything can be rationalized by invoking suitably specified transaction costs. Perhaps, an example of this problem is the conclusion Wallis and North (1986) reached about the American economy, namely that 45% of national income was devoted to transacting in 1970.

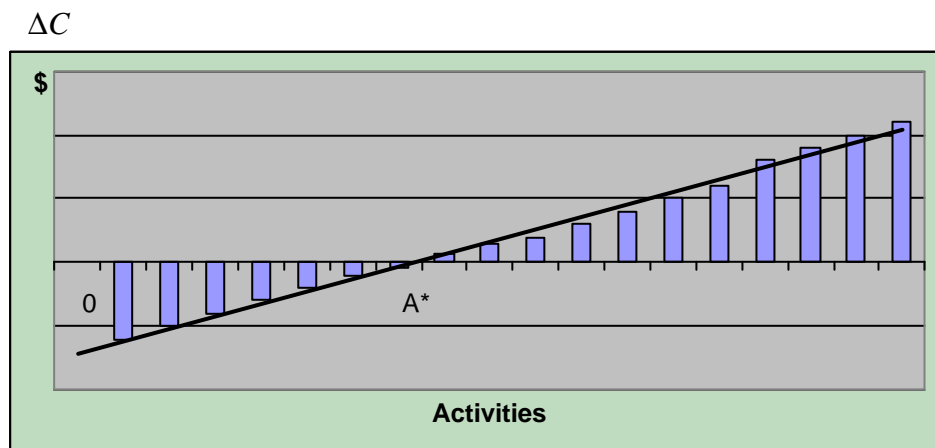
Another criticism of the TCT concerns its neglect of firm capabilities. For instance, Langlois (1992) has pointed out some worth noting elements regarding this neglect. First, in a graph, reproduced below in Figure 1, the boundaries of a firm are clearly indicated at the point  $A^*$ , hence the segment  $OA^*$  illustrates activities within the limits of the company. In this figure,  $\Delta C$  represents "...the normalized per-unit cost premium the firm must pay for the output of a particular activity if it integrates into that activity, measured relative to the per-unit cost it would incur by obtaining the output on contract from a distinct firm. Whenever this premium is negative, there is a cost advantage to internal organization..." (p. 109).

Second, Langlois (Ibid) remarked:

*"The cost premium, and therefore the location of  $A^*$ , will depend on a number of factors. As transaction-cost economics suggests, it will depend on the bureaucratic costs of internal organization and the transaction costs of market relations. But in this story, the location of the  $\Delta C$  curve also depends on the internal capabilities of the firm and the external capabilities available in the market. That is to say, the price premium includes both governance-cost and production-cost differences..."* (p.110)

Hence, according to Langlois 'production-cost differences' include firm capabilities, which encompass, *inter alia*, the organization of the company, that is, how the routines of the humans and machines are linked together. In the long run, however, transaction and governance costs tend to become zero as activities become increasingly routine. In the end, as capabilities themselves change over time, the firm boundaries change accordingly.

Figure 1



Source: Langlois (1992)

Langlois and Robertson (1995) in their comprehensive study of firms, markets and economic change have extended Langlois's (1992) analysis. The Table 1 summarizes some of their findings regarding the firm's evolution through time.

Table 1 The effects of spreading knowledge on the boundaries of the firm

	Degree of idiosyncrasy	Transaction costs	Availability of particular capabilities	Uses for particular capabilities	Relative cost of internalization	Degree of vertical integration
Short run	High	High	Thinly distributed	Few	Low	High
Long run	Low	Low	Widespread	Many	High	Low

Source: Langlois and Robertson (1995, p. 42)

In this Table 1, it becomes obvious that there is a continuous interplay between capabilities and routines versus transaction costs through time and also as these two authors show between firms and industries (Ibid, pp. 43-45). In addition, transaction costs become dynamic in the sense that they express the costs of persuading, negotiating, coordinating, and teaching outside suppliers. The degree of idiosyncrasy needs some extra clarification: "...The idiosyncratically synergistic resources that bind organizations together are, in fact, most frequently forms of knowledge that are difficult both to acquire and to communicate to others..." (Ibid, p. 13) Overall, how the firm evolves heavily depends on its capabilities, besides its transaction costs and its strategies (though the latter are not shown on that Figure). Finally, capabilities and organization of resources are also linked together: "...How the firm is organized- how the routines of the humans and machines are linked together- is also part of a firm's capabilities..." (Ibid, p. 16)

Hodgson, (1998) also makes the distinction between a TC-based theory of the firm and a competence-based theory. For instance, he argues that a firm cannot be broken down into self-employed producers trading with each other not because of higher TC, but because of entrepreneurial, managerial skills, and practical knowledge existing in an organized group of individuals (p. 183 and 192). This argument will be taken up again in the following sub-section.

In a similar way, Kogut and Zander (1992) emphasized the role of knowledge of the firm:

*"...This article seeks to lay out an organizational foundation to a theory of the firm. To replace Polanyi's puzzle of tacit knowledge, organizations know more than what their contracts can say. The analysis of what organizations are should be grounded in the understanding of what they know how to do..."* (p.383)

Note that the idea that '*organizations know more than what their contracts can say*' is a theme often encountered in several extracts of books and articles. For instance, Coriat and Dosi (1998) remarked: "...It might be generally misleading to reduce what ever pattern of intra-or inter organizational relations to a set of 'contracts' (whether optimal or not)" (p. 124).

How is this tacit knowledge related to capabilities in a more concrete way? Khalil (1996) in his review of TCT examined three separate approaches in order to describe the nature of the firm. First, according to the transaction-cost approach, neither the firm nor the

market is seen as an organization as both of them are simply different forms of governance. Second, the firm competence is about organizational capital, cultural and motivational values, as well as enclaves for interaction and learning. And third, the process view emphasizes path dependence, routines, habits, norms, or generally institutions. However, Khalil concluded:

*“...What sets one organization apart from another is strategic action...the three major approaches to the theory of the firm basically cannot account for the asymmetry of power and purposeful action...” (p. 299)*

In addition, Khalil (1996, p. 295) refers to Demsetz and Pitelis to complement his analysis on the competence-bundle perspective. The former argues that firms arise when there are, *ceteris paribus*, management economies of scale due to the reduction of production cost generated by teamwork. The latter author argues that it is supervision within the firm that reduces production costs.

The above quotations and references suggest that besides the elements of TCT, we also have the following points that constitute the nature of the firm:

- Capabilities (generic concept)
- Organization between humans and machines
- Routines
- Culture and motivation
- Tacit knowledge and learning
- Teamwork and supervision
- Strategic and purposeful actions

However, there are some other traits of TCT as these have been laid down by Coase (1937), and yet ignored by scholars in general. Thus, Coase (1937, pp. 396-7) says that a firm will tend to be larger, the less the costs of organizing, and the less likely the entrepreneur is to make mistakes. In turn, “...the costs of organizing and the losses through mistakes will increase with an increase in the spatial distribution of the transactions organized, in the dissimilarity of the transactions...” For example, inventions such as the telephone tend to reduce the cost of organizing spatially. Furthermore, “...all changes which improve managerial technique will tend to increase the size of the firm...” Consequently, we have the following elements to complement the above bullet-type list:

- Spatial distribution of transactions
- Mistakes by the entrepreneur
- Managerial technique

To make the above concepts a bit more concretely related to a particular situation, let me mention the work by Coriat and Dosi (1998) again. They argued that Taylor had the pioneering understanding that organization of production is equivalent to questions of know-how and competence. Hence, Tayloristic practices represent a “...coevolution

between forms of incentive governance, routines, competences, under circumstances of acute interest conflict...” (p. 114).

This brief review of concepts begs at least the following question: could we more precisely define the firm capabilities, apart from ‘individual or team competences-skills and tacit knowledge’, or routines, and so on? Together, all the above elements coming from different directions and theories, are apparently either in conflict with each other, or overlapping in nature, or not interconnected. For example, what did Coase mean by ‘managerial technique’ and how is this related to routines and capabilities? Or how is the element of ‘organization between humans and machines’ related to ‘mistakes by the entrepreneur’? My endeavor will be to find a proper ‘niche’ for all these elements and many others and at the same time create a comprehensive and interconnected framework for all of them so that they can be used in a systematic way for any purpose. In other words, a taxonomy of costs and benefits is needed.

## **1.2 THE FUNDAMENTAL TAXONOMY OF COSTS AND BENEFITS**

(For acronyms see also last page)

In this sub-section, I take an example that will lead me to some alternatives with easy to see consequences on the way a firm is organized and functions. Suppose a bicycle is produced only by individual producers, each one of them producing only a part of it, or assembling parts of it. Also, suppose for simplification that there are 15 parts needed to produce and assemble a bicycle. Then, we have 15 individual firms, located in different areas of a city. In this extreme case we have the following costs involved in producing bicycles (a given individual entrepreneur-worker F –a man for simplicity- is taken as the first example).

First, we have the physical costs (PCs) involving the quantity of labor of the entrepreneur-worker, the corresponding rent of the quantities of machines and tools the F uses in producing his part, and the quantity of intermediate goods (L, K, and M respectively). Second, we have the transaction costs (TCs) between F and the other individual producers with whom F’s produced part is connected. These costs involve short and long term contracts between F and his suppliers and or his customers.

Third, we have the kinetic costs (KCs), which are due to the following reasons. The F’s business premises consist of a certain area split into various sub-areas where he performs various tasks related to the diverse stages of production of the part. The way the layout is organized in terms of machines, tools, and other facilities determines his every moment movements during the day. These daily movements also depend on the way he has organized the sequence of stages or sub-stages and the timing between them.

Fourth, we have the strategic costs (SCs), which are due to the various decisions the individual producer makes regarding various issues of production, such as choice of and relations with suppliers and customers, choice of embodied technology, determination of prices, planning of production and so on. All these decisions are subject to mistakes, hence the involved costs. Finally, we have the wisdom costs (WCs), which include self-



education and training, tacit knowledge and experience, self-motivation, leadership over his dealings with suppliers and customers, and information flow between him and the latter.

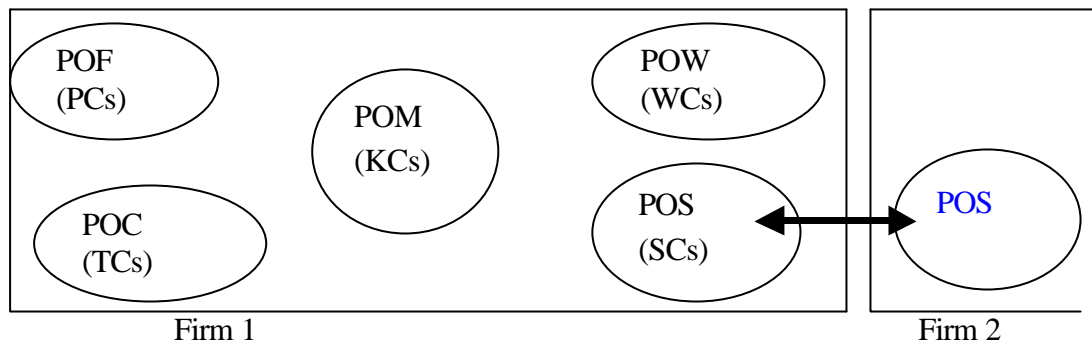
Whenever we have costs we also have gains. Hence, the above 5 types of costs can also be benefits, hence costs and benefits (CBs). In addition, the link between costs and benefits can be thought to exist in the evolution process of each type. Consequently, the evolution or process of wisdom can involve costs and benefits of wisdom, and so on. Thus we have the following 5 processes: that of strategies (POS) (related to SCs), that of movements (POM) (related to KCs), that of contracts (POC) (linked to TCs), that of wisdom (POW) (linked to WCs), and that of K and L factors (POF) (related to PCs).

Another way to look into the 5 processes of costs and benefits (POCBs) is to contrast them with concepts of other sciences. The production of the bicycle part necessitates some kinetic energy (KCs) with some friction (TCs) to properly use K and L (PCs), subject to the generated heat (WCs) and collisions (SCs). This comparison with these laws in physics was not intended *a priori* but it seems as if the 5 economic costs fit well with them. If this comparison is not completely satisfactory, I can also contrast the 5 CBs with a human organism. In this case, the POW is the brain as a container of wisdom, the POS is the brain as a center for decisions, the POF is the main body with legs and arms, the POC is the skin, and the POM is the various movements and work accomplished by the human being.

All these 5 costs are inter-dependent but they can be considered as being separate entities from a conceptual view. For example, a different layout on the shop floor, or a different sequence of sub-stages of production will perhaps entail a new ratio of L to K, or a new type of tools, or it will have an impact on experience and tacit knowledge, and so on. Also, a different type of tools and machines will perhaps influence the strategic process, which in turn will have an impact on the layout of the shop floor, and so on. The combination of the 5 processes is a necessary and sufficient condition for the existence of these individuals firms in our example, and their dynamic evolution through time and space.

Furthermore, there is no overlapping between the 5 types of costs or the corresponding processes, because each one of them is linked to a separate aspect of the overall process of production. Thus, for example, the wisdom process and costs belong to a distinct sphere of states and changes, as there are no elements of the other processes, which also belong to the wisdom process. To express all this a bit more formally, we can use the concept of sets for POS, POW, POM, POC, and POF and observe that these do not intersect each other. Figure 2 illustrates the outcome. Although not shown on the figure, arrows between each pair of processes would indicate their interdependence; also, we can compare the firm with a lake, in which the 5 boats of POCBs are floating, always approaching each other or getting away from each other. In this figure, a second firm is shown as well with its own POS, which interacts with that of firm 1.

Figure 2 The 5 POCBs and firms



From this example so far, it can be seen that it is necessary to distinguish between the 5 types of production process because they involve distinct types of costs and benefits (CBs, e.g. TCBs, KCBs, etc). Any analysis that uses these 5 different CBs will be able to perform better than if only four or fewer CBs are used. The analysis below shows this point. Returning back to the example, let us suppose now that two of the individual producers “discovered” through their processes of wisdom and strategies that they could get together, cooperate and produce their own parts in a joint manner. Thus a new firm is now created replacing two old ones. What could be the reasons for their decision to merge? The answer lies in examining the 5 processes of CBs (POCBs) separately.

First, the KCBs are at the core of important changes. The two individual producers by helping each other can now speed up some sub-stages of production on the shop floor, by rearranging the layout, the sequence of steps, and the timing. For example, if before the merging, one firm produced the main metallic tubes and the other firm produced the wheels, now the two individuals can join their efforts in producing both items and assembling them as well. Thus, we can assume that jointly they can now make and assemble 8 sets of cylinders and wheels in a week, whereas before the merging took place they could only produce 7 cylinders and 6 wheels separately. Consequently, by combining their efforts and changing the organization of their work on the shop floor they increase their productivity significantly.

However, the merging of the two individual firms also creates a new situation from the TCBs point of view. First, the two partners must now find a common ground regarding their mutual and parallel operations according to which they can form a contract about all the issues involved, for instance about how to share their division of labor, how to share their profits and so on. Second, between the two partners, the elements of some coordination and leadership are now needed; they can include these elements in the formal contract or they can just agree on them informally. And third, very probably they have to reconsider their contracts with suppliers and customers.

Regarding the PCBs the situation after the merging is also different. The quantity of L remains the same (two workers now working together instead of two before working separately). However, the amount and perhaps quality of K is now different in several ways. First, new premises are needed to shelter the new combined shop floor and overall

business. Second, some of the machines and tools on the shop floor are now redundant, due perhaps to duplication, and probably some new equipment is now needed to accommodate the joint effort of the two individual entrepreneurs-workers. And third, some equipment for carrying out administrative tasks, such as a fax and a computer, need to be now eliminated if it is duplicated. Overall, the PCs are dependent on the KCs and perhaps vice versa. In other words, normally, it is better to first determine the most efficient way of organizing the shop floor and then determine what capital is needed, although sometimes it is possible to have some constraints as to the specific equipment available in the market and hence these constraints will in turn impact on the KCs.

The WCBs are also influenced by the merger. The two businessmen must now learn how to work together, how to play the roles assigned to themselves of their business in all aspects, eventually train themselves in new areas; they will also acquire new experiences, skills and tacit knowledge. These WCBs primarily depend on the KCBs because what takes place on the shop floor influences everything else in the business. To a lesser degree, they also depend on the PCBs and TCBs, for instance the adopted equipment and its usage might necessitate some new training, or the nature of contracts signed have an impact on the way the tacit knowledge develops, and so on.

Finally, the SCBs are also affected by the merger. New avenues of expansion are now open to the new firm, hence some important decisions must be taken as to how to expand and in what directions. These SCBs are affected primarily by the KCBs and the WCBs, for example, the new shop floor might allow a further expansion by integrating another part to produce internally.

Taking up the last point, let us assume now that our two partners realize that a particular part of the bicycle now produced by an independent individual firm, say for argument sake, the handlebars could be also produced internally with the prospect of increasing their profits and market power and share. Within the framework of SCBs, they took the decisions to train themselves as to how to produce the new part, and to hire an apprentice or an experienced worker who could help them in the whole process of producing all three parts, their own (main cylinders of the skeleton and wheels) plus handlebars. In brief, some of the obvious changes in all 5 CBs will now be summarized.

First, the whole process of producing all three parts under the same premises is revised and reestablished in detail in order to accommodate an extra labor unit, some extra equipment, and so on (hence the KCBs are affected). Second, as a consequence of the proposed changes on the shop floor, L and K are also affected (hence, the PCBs are modified). Third, new contracts, formal and informal must be shaped and signed by all three participants (hence, the TCBs are amended). Perhaps, the new expanded firm now needs a different type of legal form to accommodate for the dual character of having partners and personnel. Fourth, new strategies, decisions must be made as to the future of the company (hence, the SCBs are adjusted). Finally, new experience, tacit knowledge, training, flow of information, and leadership are generated (hence, the WCBs are altered).

It becomes by now apparent how easy it is to analyze new situations of a firm's evolution by appropriately using the 5 CBs of the corresponding processes. Some other cases can be in the same way explored. For instance, let us assume that the above company decides to expand until it incorporates all parts of producing a bicycle, thus eliminating from the market all other remaining 12 individual producers (the new super firm called firm F1 from now on). In this case, all 5 CBs are accordingly affected again. Once more, the KCBs are usually the ones to be first determined since the actual production takes place on the shop floor, which is the core of every business. An assembly line is now necessary to speed up all stages, thus creating new procedures, timing, and coordination. This in turn necessitates more labor to be hired, trained and contacted, as well as new equipment and new premises (PCBs and TCBs). The new governance necessary to run the business will also affect the TCBs, hence a new legal company form will emerge and more contracts with the employees will be signed. Eventually, a new set of capabilities will be generated (WCBs) and a different set of strategies and decisions will be taken to expand the firm into new horizons (SCBs).

Now, suppose that this new firm expands quite rapidly in the next few years. How are the 5 CBs and corresponding processes affected? First, and most important, the POM and KCBs are modified to accommodate the growth by becoming more efficient in terms of schedules, assembly lines, layouts, procedures, routines, timing, and so on. New systems are adopted that are more related to the mass production overall process, and at the same time, quality control and just-in-time inventories are introduced to make the process more flexible and less costly. Second, the quantities of L and K (POF) are adjusted accordingly in order to accommodate the new POM. Third, a public company is formed with new contracts with the employees and suppliers as well as customers (POC) in order to reduce opportunism and enhance trust. Fourth, the POW is extensively modified to include R&D, new training schemes for enhancing the skills of workers, and a new marketing intelligence to discover new market outlets. Finally, the POS is now a true nest of continually grafting new more effective strategies to remain a large enterprise and to continue to grow nationally and globally.

Let us pause for a moment to examine the following possibility. Instead of the above firm being based on the initial partnership of two individual producers and all subsequent additions to labor being based on hiring workers, let us assume that the fully integrated firm producing all 15 parts as one company is governed by a multiple partnership of the initial 15 individual producers (called firm F2). What are the consequences on the 5 CBs? The main difference between F1 and F2 concerns the POC. Profits under F2 would be smaller than profits under F1, since the wages under F1 disappear and become profits under the governance in F2 (supposedly, under partnership conditions in F2 partners are regarded as principals and hence they claim higher rewards than under simple principal/agent conditions in F1 in which the hired labor is paid simple wages or salaries). In addition, very probably, the POS would also be significantly affected because under a regime of 15 partners it becomes more difficult to have complete agreements on strategic issues. The remaining processes POM, POW, and POF would also be affected but to a lesser degree.

A final alternative, an opposite situation to the one just described in the previous paragraph, will provide us with extra valuable information. Assume that one of the initial individual entrepreneurs, who lost his market share completely because of the firm F1, has decided to form a rival firm (F3), which would produce the whole bicycle under his ownership. His decision was supposedly based on a new technical (embodied technological) innovation (TI) and a new organizational (disembodied technological) innovation (OI) that would increase productivity substantially. What are the main impacts on the 5 POCBs? First, the absence of a partner would probably alter the entrepreneur's POS and POC quite drastically. Second, the introduction of his TI would modify both the POF and POM quite significantly. Third, the introduction of his OI would change the POM and POF again quite extensively. And fourth, all these transformations would in turn impact on the POW quite notably.

The 5 POCBs constitute the fundamental elements of producing work: we need knowledge (POW) and rules (POC) in order to decide (POS) how much of each factor (POF) is efficient to execute (POM) the desired work. If we only have rules, quantities of factors, knowledge and decisions, work cannot take place unless there are the right movements of execution and effort. Thus, the POM is the 'heart' of the firm. In this respect the following schema will help grasping the most probable sequence of interdependence between the various POCBs.

POS → POW → POM → POF → POC → POS → ...etc.

Of course, it is possible that once we are at one particular POCB the sequence is reversed in order to get feedback, for example,

POM → POW → POS → POF → POC → etc.

Nonetheless, it remains valid that the initiatives are taken by the POS (which is not necessarily represented by the upper management, but also by the participation of many other employees) in order to change the POM on which the whole production system depends. These initiatives can spring from the two types of technological innovations, namely the OIs and TIs. The TIs, though in terms of R & D belong to the POW, are finally incorporated into the POF as intermediary goods, or machines, and so on. However, very rarely if ever the OIs are not affected at the same time as a TI is introduced; thus, the POM is changed, and hence the other POCBs as well. If the initiatives of the POS are generated by the will to introduce an OI, then the POM is primarily affected, and in turn all the other POCBs are affected, including the POF if TIs are also introduced as a parallel act to the new OIs.

To summarize my findings so far, the Table 2 shows all the elements belonging to each POCB in detail. Some comments are necessary here in order to clarify the boundaries and content of each POCB. The third line describes the nature of each process; thus, the process of contracts (POC) is the superstructure of the firm because it is 'above' or it governs the structure of the firm, which is simply the various factors of production (POF); in contrast, the process of movements of these factors is the inner or infrastructure

of the firm; the POW represents the survival instinct and capabilities of the firm; finally, the POS is the drive for power by taking appropriate initiatives and decisions. The fourth line describes the essence of each process by referring to some key words that complement the meaning of the acronyms POM etc; thus, for example, the POW is about the ability and the memory a firm has to face the world. The sixth line expresses the main economic purpose of each process; thus, the aim of the POC is to produce as less friction as possible, the target of the POM is to produce as less waste as possible, and so on.

All the other lines below the sixth line contain the main elements of each process. Thus, the quantities of inventories and defects are part of the POF only; the teamwork effort through coordination, appropriate layout, procedures, timing and organization, which all involve movements of some sort are part of the POM only; anything related to knowledge and accumulated abilities of wisdom are part of the POW only, for example, culture, the ability to undertake R&D, the ability to motivate and being motivated, and so on. The existence of opportunism, incentives, trust, standards, and so on are a consequence of the rules established in the firm through various types of contracts, and hence they are part of the POC only; finally, any initiatives to create power and momentum in the business environment, which involve strategies, vision, planning and so on are part of the POS only. Of course, any element of any POCB can and does influence any element of any other POCB.

The relationship between the 5 POCBs and economic growth becomes now more evident but also, unfortunately, more complicated. The usual production function so often used in economic essays of economic growth is primarily concerned with the mechanisms of POF, that is the quantities of the various factors of production, and their mutual substitutions; more recently, the quality of labor and capital have also been included in these production functions, thus touching on elements of the POW (e.g. education). However, in order to properly explain economic growth, we should include all elements of the 5 POCBs, a rather impossible task since most of these elements are very difficult to quantify. Through the expedience of the concept of TFP, everything, which is not explained by the physical factors of production or their qualities, is attributable to the content of TFP; this substance is very often a vague technology or ...anything else. In the analysis presented in my study, TFP can be attributed to the POM, or POC, or POW, or POS; but, since all POCBs are interdependent, also, the POF depends on TFP and *vice versa*.

As a conclusion to this sub-section, it is wise to recapitulate the links between my propositions contained in the traits of the Table 2 and what the relevant literature has already proposed. Some of these traits are recognizable; scholars in economics have always paid attention on the POF, recently on the POC and to a lesser extent on POW. Labor and capital, or more precisely their quantities have always been the economists' preoccupation as to how these two factors have an impact on numerous economic phenomena. Almost the same conclusion holds for the POC, which has received a substantial attention only in the last 30 years or so, despite the seminal article by Coase earlier in 1937. Regarding the POW, the concept of human capital and its importance have been analyzed quite substantially, as well as some other elements of this process

mainly by management scholars. The POS has also been the target of the management discipline, mainly through the so-called strategic management stream. Finally, the POM has mainly been the object of analysis of the operations management, again almost completely neglected by economists.

Furthermore, the famous ‘division of labor’, described by Plato, Smith (1776) and others, is primarily the POM, POC, and POF in my analysis. Hence, division of labor becomes more precise and related to the whole process of a firm’s expansion. In Smith’s pin factory, no mention was made to the effect of differences in how many alternatives exist in organizing the division of labor in terms of space, time procedures (which is what the POM tells us), nor to the effect of governance and trust in terms of transactions (which is what the POC tells us), nor to the effect of the various quantities of all inputs that might produce a given output (which is what the POF tells us). Of course, the POF has been subsequently thoroughly incorporated into the analysis of division of labor by numerous other scholars.

In addition, the term ‘capabilities’ of the relevant literature can now be more precisely pinned down according to the proposed theory here. Thus, any elements of the POM, POW and POS are part of these ‘capabilities’. Hence, it also becomes evident that the distinction between the production function (POF) and the governance function (POC) according to Williamson’s work (1996) is not sufficient to explain the existence and evolution of firms. Capabilities are needed as well, as represented by POM, POW and POS.

Finally, it is worth mentioning that my propositions are close to a limited number of writers’ ideas and concepts, but very probably only partially so. For instance, Hagstrom and Hedlund (1998) suggested a three-dimensional model of the internal structure of the firm comprising position, knowledge, and action. The positional structure is the most stable and the most hierarchical; knowledge is structured more horizontally, temporarily and circularly; and the action structure represents the axis strategy versus tactics. Comparing their model with mine, it seems that the POC is equivalent to their positional structure, the POS is equivalent to their action structure, and the POW is equivalent to their knowledge structure. If we omit the POF, which usually represents the classical production function, then there is still the POM that is missing.

Also, Coriat and Dosi (1998) wrote:

*“...The path-dependent, often organization-embodied, nature of knowledge makes corporate structures the prime carriers of diverse problem-solving skills, to a good extent stored and reproduced via organizational routines...”* (p. 123)

In this case, the ‘organizational routines’ are analogous to the POM, the ‘path-dependent knowledge’ is akin to the POW, whereas the ‘diverse problem-solving skills’ belong to all the four POCBS (hence excluding the POF).

Table 2 Elements and traits of each Process of Costs and Benefits (POCB)

<b>POM</b>	<b>POF</b>	<b>POC</b>	<b>POW</b>	<b>POS</b>
<b>Process of movement</b>	<b>Process of factors</b>	<b>Process of contracts</b>	<b>Process of wisdom</b>	<b>Process of strategies</b>
<b>Infrastructure</b>	<b>Structure</b>	<b>Superstructure</b>	<b>Survival</b>	<b>Power</b>
<b>Movement relations between factors of production</b>	<b>Quantity relations between factors of production</b>	<b>Rules of the relations between the factors of production of POF</b>	<b>Ability and memory</b>	<b>Initiatives for action</b>
<b>Kinetic costs</b>	<b>Physical costs</b>	<b>Transaction costs</b>	<b>Wisdom costs</b>	<b>Strategic costs</b>
<b>Purpose: to produce less waste</b>	<b>Purpose: to use fewer factors</b>	<b>Purpose: to produce less friction</b>	<b>Purpose: to produce less negative knowledge</b>	<b>Purpose: to produce fewer mis takes</b>
Timing	Quantity of labor	Contracts with employees	Experience	Strategies
Procedures	Quantity of machines	Legal form of the firm	Tacit knowledge	Everyday decisions
Space	Quantity of tools	Contracts with suppliers	Education and training	Planning
Layout	Quantity of space	Contracts with customers	Culture	Vision
Routines	Quantity of materials and intermediate goods	Contracts with society	Information flow	Mission
Teamwork	Energy	Legal standards	Competences	Objectives
Coordination	Inventories	Accounting rules	R&D	Attacks
Implementation	Defects	Institutions	Imitation	Defense
Execution		Governance	Innovations	Inertias
Organization		Trust and risk	Leadership	Momentum
Effort non-physical		Standards	Techniques of analysis	Power
Effort physical		Authority	Needs	Domination
Fatigue		Control	Motivation	Initiatives
Cooperation		Opportunism	Exploitation	Thinking
Work satisfaction		Ownership	Bounded rationality	Inspiration
		Incentives	Idiosyncrasy	Uncertainty
			Marketing Intelligence	Forecasting



### 1.3 THE CREATION AND EXISTENCE OF FIRMS

(For acronyms see also last page)

The analysis of the first section with the aid of some examples provides us with some first insights into the definition of a firm and its evolution. In this section I will make this definition more explicit.

An ideal and broad definition ought to include the following statement: a firm is created every time the number of units of labor (or any other factor of production) is increased or decreased with the aim to increase production and especially productivity. This change in the units of labor is general in nature. For instance, if we have a modification in the ownership status of the firm, (such status constitutes one of the main strong human values of all societies) then there is modification of L (at least) and hence a new firm is generated. However, what really matters is the re-organization that is necessary if we increase or decrease L in order to change productivity. If K varies for the same purpose, then a re-organization takes place; hence a new firm is formed in that respect. Consequently, for practical reasons any modification in L or K or M lead to a new firm. Nevertheless, we know now that any alteration in the quantities of the factors of production entail or come from changes in the other 4 POCBs and vice-versa. Consequently, any change in any of the 5 POCBs would generate a new firm. Thus, my suggested definition of the creation of a firm is summarized as follows: every time there is a change in at least one of the five POCBs, there is a new firm.

This analysis is similar to the one proposed by Kaldor almost 70 years ago. It is worth noting his proposition.

*“...The most satisfactory definition of a firm is that of a ‘productive combination possessing a given unit of coordinating ability’...Firms whose coordinating ability changes, while preserving their legal identity, would not remain the same firms; but then all the theoretically relevant characteristics of a firm change with changes in coordinating ability. It might as well be treated, therefore, as a different firm...” (Kaldor, 1934, p. 69 and p. 70)*

Note that Kaldor’s ‘coordinating ability’ very probably encompasses all POCBs of my analysis except the POF.

As an illustration of my proposition, suppose that a person offers his labor in the first place in his own firm, and then decides to hire an employee in order to be more productive, we have the creation of a new firm, because the above conditions are met: first, the addition of an another unit of labor will entail many changes in the new firm with the aim to increase productivity, and second, the hiring of an employee will change the status of ownership relations within the new firm, this time there will be a contract between an authority and an agent. If a person is an employee in an existing firm, and subsequently decides to work for himself in order to be more productive (hence to increase his income or profit), then we also have the creation of a new firm because again we have the above condition met. The same story is repeated if an existing firm is merged with another one, or if it expands vertically, and so on. Consequently a firm exists from the moment it has at least one unit of labor and endeavors to produce something that can

be sold in various markets with the aim to satisfy the aims and aspirations of the owner(s) and employees of the firm. It seems that this analysis allows for a perpetual creation of an enterprise.

It is now possible to answer some basic questions hovering in the articles and books of the relevant literature. First, what are the reasons for the creation and existence of firms? The answer lies in the exploration of the 5 POCBs, first separately and then all of them simultaneously. First, and perhaps most important, the POM can increase productivity and hence profits considerably, once the passage into a larger firm is made (for example, from none to 1 unit of labor, from one to two, or from 5 to 12, or from 100 to 160, and so on). The reasons for this increase are the advantages of the specific elements that the POM contains, such as routines, teamwork, etc. For instance, procedures and routines of assembly lines can always be improved through the introduction of either a TI or an OI, or both of them. In this respect, I should make a note that often it is necessary and unavoidable to form a team in order to carry out a particular task (for example, if an item is too heavy to be lifted by one person, then a group of workers will lift it), and hence a firm is formed to do so.

Second, the POW can increase productivity and hence profits considerably, once the passage into a larger firm is made (for example, from none to 1 unit of labor, or from one to two, or from 8 to 15, or from 156 to 254, and so on). This can be achieved by enhancing experience, information, competences, and all the other elements of the wisdom process. For example, if imitation of foreign technologies can be easily achieved then new growth is possible, by starting a firm or expanding an existing one. Third, the POC can have the same effect as the previous two processes. This can be accomplished by more flexible and effective contracts, better institutions, and so on. Fourth, the POS can also increase the productivity of a firm (hence a new firm is created) by the virtue of the specific elements of these two processes. For instance, the possibilities of having a new vision and of crafting new strategies are a sufficient condition to form a new firm. And fifth, the acquisition of new equipment containing technical innovations within the framework of the POF has the potential to create a new firm.

However, a change in each one of the 5 POCBs separately is not sufficient. We must also compare all variations in all these 5 processes to evaluate the resultant costs and benefits. If all added benefits exceed all added costs, then the creation or the modification of a firm takes place. The evaluation of these CBs can of course be based on wrong assumptions due to bounded rationality and incomplete wisdom, and hence mistakes can easily occur leading to wrong decisions, disappearance of firms, creation of firms that should never have been created in the first place, and so on.

The second question is: what are the reasons for the expansion and development of firms? A corollary of this question is: what is economic growth due to? The answer to the first sub-question is already embodied in the definition of the firm I gave above, according to which a firm is perpetually created and hence expanded each time we have changes in the 5 POCBs. The purpose to increase productivity leads to changes in any one of the 5 POCBs, which in turn leads to firm growth. If most of firms in an industry grow this way,

and if most industries grow as well then we have an overall economic growth. Though this growth is based on increasing returns to scale due to increases in productivity, extra growth can also take place through a part of firms and industries which grow under the regime of constant returns to scale. Furthermore, the simple expansion of existing firms, without a contemporaneous creation of other firms can also lead to growth if the resulting changes in the various POCBs have an overall positive outcome.

The third question is: what are the main roles of the leaders entrepreneurs and managers? According to the taxonomy of costs and benefits I am proposing here, these leaders are more directly related to the POW and POS than to the other processes because they implement the promotion of wisdom and effective strategies for a sustainable and increasing productivity. However, their input is also indirect into the other processes, the POC, the POF, and the POM.

To conclude this sub-section, I will show the functioning of the system of the 5 POCBs with an example, namely the successful implementation and working of the Just-in-Time cum Quality Control (JIT/QC) process in a firm. The consequences for each one of the POCBs are as shown in Table 3.

Table 3 Cost and Benefits of the 5 POCBs

<b>POCB</b>	<b>SOURCE OF CHANGE</b>	<b>COSTS</b>	<b>BENEFITS</b>
POF	Reduction in L		+
POF	Reduction in existing K and M		+
POF	Increase in new K and M	--	
POM	Reorganization of procedures etc: mistakes, extra time, trial and error process until JIT/QC is implemented	--	
POM	Running of the JIT/QC process		+
POC	Implementation of new contracts, standards, rules etc	--	
POC	Running of new contracts, standards, rules etc		+
POW	Training and education of staff for the adoption of JIT/QC	--	
POW	Development of new techniques of analysis	--	
POW	Accumulation of wisdom, knowledge etc		+
POS	More time for thinking and taking decisions during implementation of JIT/QC	--	
	Quicker decisions and better strategies during the running of JIT/QC		+

The next step is to estimate the resulting overall benefits by combining the 5 POCBs. This is shown in Table 4.

Table 4 Resulting overall benefits

<b>POCB</b>	<b>SOURCE OF CHANGE</b>	<b>NET BENEFITS</b>
POF	Mainly due to reduction in L	++++
POM	Mainly due to better procedures of teamwork	++++
POC	Mainly due to better governance and trust	++
POW	Mainly due to more abilities	+
POS	Mainly due to less decision making	+
TOTAL	All the above	+++++

Thus, overall the implementation of JIT/QC generates substantial net benefits to the firm (plenty of evidence for the existence of these net benefits is provided in Sanidas, 2001). The measurement of the overall total balance of net benefits can be gauged through the measurement of changes in labor, or capital, or total productivities due to the implementation of JIT/QC (that is, before and after JIT/QC is running successfully).

If we want to measure the net benefits for each PO CB, we should adopt the following procedure. First, in order to calculate the net benefits for the POM we must measure the changes in the POF without changing the POC, POW, and POS (which is possible if we do not change contracts, training, strategies etc). Second, in order to calculate the net benefits for the POC we must measure the changes in the POF without changing the POW and POS after the POM is implemented in the first step. Third, for the evaluation of the POW, after the completion of step two, we only hold constant the POS and make the appropriate changes in the POW in order to see the ensuing net benefits. After the completion of step three, we finally can make changes in the POS in order to calculate its effects on productivity. If we could carry out another test, we would measure the changes in net benefits when two or three of the PO CBs are altered at the same time. In this way, these results could indicate the synchronic effect of the relevant PO CBs and hence the marginal effect of individual PO CBs (when compared with the results of the first experiment).

Of course, such a procedure in practice is virtually impossible, though it could be completed as a very expensive experiment. Consequently, we can only measure the overall effect of the four PO CBs based on changes in the POF, thus measuring labor or capital or total factor productivities. Once more, in economics we are deprived from the luxury of experiments so common in other sciences (hence in this respect economics and astronomy are perhaps the most known sciences which cannot 'afford' the advantages of free experiments). However, like many other theoretical concepts, such as endogenous growth and transaction costs, it is natural that it takes time before a sound methodology is devised whereby measurement of the individual effect of each PO CB becomes worthwhile, possible and significant. Besides, the use of proxies in econometrics is well known in this regard, once these proxies are 'discovered' and are well justified analytically.

## 1.4 LINKS WITH THE MAJOR HISTORICAL PRODUCTION SYSTEMS AND OIs

(For acronyms see also last page)

The relation between the 5 POCBs and the major production systems (PSs) can now be analyzed. As it has been seen in the previous chapters, several relatively distinct industrial processes of production were implicitly determined: the handicraft system, the putting-out one, the factory process, the mass production one, the lean production system, and perhaps the internet production system that is still emerging. The evolution of these production processes through time can be gauged by considering the importance of each POCB for each one of these systems. For this purpose, I will use a scale from 1 to 6 to indicate the increasing positive effect of the POCBs (thus, the score 6 would mean the most positive, whereas 1 would mean the least positive). The following Table 5 summarizes my judgment; hence a strong element of subjectivity is included. However, the fact that one system has replaced another would mostly support my verdict (hence it is an *ex-post* 'prediction').

Table 5: Relative importance of the 5 POCBs in the historical evolution of industrial modes of production.

	Handicraft	Domestic	Factory	Mass	Lean	Internet
POM	1	2	3	4	5	6
POF, for L	1	2	3	4	3	2
POF, for K	1	2	3	4	5	6
POF, for energy	1	2	3	4	5	6
POC	5	2	3	3	4	4
POW	1	2	3	4	5	6
POS	3	2	2	3	4	4
Total	13	14	20	26	31	34

In the Table 5, I have numerically linked the evolution of PSs with some obvious facts. The quantity of labor has reached a maximum with the mass production system, but it has since then been decreasing. On the contrary, the quantities of capital, energy, as well as the benefits of POM and POW have been monotonically increasing. The POM has been more and more productive because better procedures, routines and other features have been improving through time thus captivating the benefits of teamwork. The POW has also been gradually more productive because wisdom increases through time.

On the other hand, the POC was at its maximum of performance in the handicraft system, because there were mostly one to two units of labor producing complete simple products. Then, with the advent of the domestic system the problems of making effective contracts started appearing and since then the POC became gradually better, though slowly, as the other POCBs improved as well. Finally regarding the POS, a similar trend to the POC has been taking place, though with a couple of differences. First, the performance of the handicraft system was only equaled by the mass production, and second, very probably the Internet system is loosing some of the abilities to take strategic and other decisions due to the competitive nature of internet transactions.

Note that the total of each PS scored in Table 5 is rather a poor indication of the performance of each PS mainly because the weight used for each POCB is equal. However, in reality such assumption seems to be very weak. Despite this flaw, it is interesting to note that the passage from the handicraft to the domestic system took almost two centuries to be completed, hence the close score between the two systems (13 and 14). Overall, my gut feeling about filling each square of the Table is only a very rough approximation of what I am trying to establish in this sub-section. A thorough analysis in this respect is of course outside the scope of this study.

The relation between the 5 POCBs and the major organizational innovations (OIs) can also be analyzed in the same way, as OIs and PSs are inherently linked. For instance, the lean production system is identified with the JIT/QC philosophy, or the mass production is based on Fordism in many respects, and so on. However, an obvious question arises: what POCB is more or exclusively linked with the OIs? Perhaps, the answer is also obvious: since the POM contains elements of procedures, routines, timing, layout etc, then OIs belong almost exclusively to the POM. However, OIs are influenced by the POW, and POS especially but also by the POF and POC. For example, abilities to accumulate tacit knowledge and culture certainly make the implementation of a new organization on the shop floor easier, hence enhancing the performance of the POM, or better contracts of a more efficient governance structure entailing more trust in the company make the OI more workable.

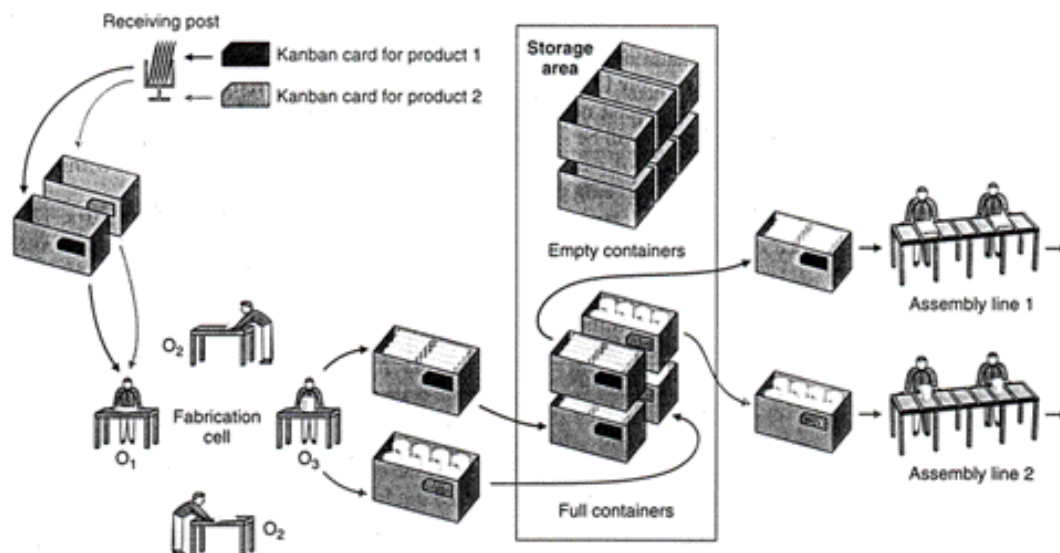
If we consider a bit more the JIT/QC system, it is worth showing the POM inside the single-card *kanban* procedure depicted in Figure 3. In this graph, it becomes clear that the POM is about movements and kinetic energy or costs, as it was explained in a previous sub-section. It also becomes clear with a bit of imagination that there are several ways of arranging these movements in the same space in order to produce a given amount of output, hence there is always room for improvements in the organization of the kinetic energy so that there is always room for increasing productivity. These improvements can occur with or without changes in the quantities of the physical factors of production, that is the POF (or even with or without changes in the other POCBs).

The implementation of JIT/QC takes a considerable time and effort and costs to complete. If we follow Krajewski and Ritzman (1999) again, more cooperation and trust is needed, thus the POC is affected; the reward systems and labor classifications need to be altered, thus the POC is involved again; the workers might feel more stressed and pushed, thus the POM is affected this time; the layouts also need to be altered, thus the POM is involved again. Regarding this last point, the two authors say "...a survey of 68 firms using JIT systems indicated that the single most important factor in successful implementation is changing product flows and layout to a cellular design..." (p. 752). Krajewski and Ritzman's analysis is not complete, and hence a more comprehensive study would indicate how all the implementation issues affect each POCB.

If we take another OI, for example the introduction of the Mform of governance, the various POCBs are affected in similar ways. Thus, the POC and the POS are primarily

involved in this case, but also the POW and the other processes to a lesser extent. It is also necessary to briefly refer to the famous division of labor once again; this division is primarily defined as the allocation of people to jobs, tasks, and activities. My present analysis with the introduction of the 5 POCBs attempts to supplement this division by analyzing how this allocation takes place; how the various tasks are carried out, how they are related to each other, and what the alternatives are. Thus, it is not only how each worker is specialized in producing one part of a pin- according to Smith's (1776) famous example - but how exactly he or she works in his or her specialization and what are the links between his or her tasks and the other workers' tasks. All these extensions of the initial Smithian labor division can also be found in the contributions of scientific management and subsequent analyses by many other scholars (see previous chapters and sections).

Figure 3 Single-Card *Kanban* System



Source: Krajewski and Ritzman (1999, p. 743)

In addition, as all the POCBs are interrelated, the division of labor depends on coordination, execution, experience, strategies, quantities of inputs, standards, control, leadership, and so on (and *vice-versa*). As Heydebrand (1989, p. 326) remarked: "...A particular division of labor may be both cause and consequence of a particular form of coordination and control..." Thus, it is possible that the division of labor becomes very detailed, precise, and rigid as it was the case with a Fordist type of production process, or it becomes more flexible and blurry as it is the case with the JIT/QC process. A good example of how TIs affect the division of labor, and how in turn some other OIs such as power relations and transaction costs affect TIs, is provided in the article by Robertson and Alston (1992). A detailed analysis between various major OIs and the five POCBs is though outside the scope of this study.

## CONCLUSIONS

The taxonomy of costs and benefits assigned to all the operations of any firm as suggested in this paper offers a new ground for analysis of the theory of the firm. This new ground has the possibilities to explore the existing concepts of factors of production, transaction costs, capabilities, and so on, in a more concrete and systematic way. In addition, it becomes a holistic and integral tool of analyzing all conceptually feasible and possible types of operations in a firm; thus, Table 2 in a previous section summarizes all the interdependent alternatives of operations and hence costs and benefits that take place during the functioning of a firm.

In that Table it becomes clear that the firm operates on five distinct but parallel levels or processes: the process of quantities of factors of production (specific quantity relations between these factors); the process of contracts (specific formal or legal relations between the factors of production); the process of generating knowledge (accumulation of abilities and memory); the process of crafting objectives and strategies (initiatives for action); and the process of actual movements and work of the factors of production (specific movements relations between these factors). For each one of these processes there corresponds a specific type of costs (and hence benefits); physical, transaction, wisdom, strategic, and kinetic costs respectively. Also, for each one of these processes there correspond a certain number of characteristics that fully describe the fundamental elements of each process.

Consequently, these five basic processes of firm operations (hence costs and benefits) can be used to analyze and describe many phenomena in the world of business, such as the occurrence of technical innovations or organizational innovations (e.g. the JIT/QC system), the creation, evolution, and growth of firms, the occurrence of the historical modes of production (e.g. the mass production mode), and so on.

Furthermore, the taxonomy of firm operations, costs and benefits suggested in this paper throws some extra light in the vivid ongoing debate as to the relevance of transaction costs, capabilities, competences, technology, and other generic concepts that are used to explain the existence and evolution of firms. For instance, according to the taxonomy suggested in this paper, technology expressed as technical innovations (as opposed to organizational innovations) are primarily an area of the wisdom and strategy processes, whereas technology expressed as organizational innovations are an area pertinent to the process of movements and the process of strategies. Any one of the five processes can potentially generate extra growth, though all processes are interdependent.

Finally, this taxonomy of firm operations, and the adjacent costs and benefits seem to unite apparently distinct disciplines such as management and economics since the five fundamental processes create a continuum of analysis of the functioning of firms from their management and formulation of strategies to the maximization of returns, under conditions of bounded rationality, and so on. This taxonomy is not static but dynamic in the same way as the aims and life of a live and competitive human being are not static.



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## ACRONYMS

TCT:	Transaction cost theory
OIs:	Organizational innovations
TIs:	Technical innovations
POCBs:	Process of costs and benefits
PCs:	Physical costs
KCs:	Kinetic costs
SCs:	Strategic costs
TCs:	Transaction costs
WCs:	Wisdom costs
POM:	Process of movements
POC:	Process of contracts
POF:	Process of factors
POS:	Process of strategies
POW:	Process of wisdom
JIT/QC:	Just-in-time /Quality control