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THE ECONOMICS OF GOVERNANCE: THE ROLE OF LOCALIZED KNOWLEDGE IN THE INTERDEPENDENCE AMONG TRANSACTION, COORDINATION AND PRODUCTION

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THE ECONOMICS OF GOVERNANCE: THE ROLE OF LOCALIZED KNOWLEDGE IN THE INTERDEPENDENCE AMONG TRANSACTION, COORDINATION AND PRODUCTION¹

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ABSTRACT. The analysis of the role of knowledge in the economics of governance provides a framework able to integrate the research programs of the resource-based theory of the firm and of the economics of transaction costs and overcome their own limits. Transaction costs economics pays little attention to organizational knowledge. The resource-based theory is not able to appreciate the role of organizational constraints in shaping the rate and the direction of the growth of the firm. In the context provided by the economics of governance the interdependence among transaction, coordination and production is modelled as a micro-system where localized technological and organizational knowledge plays a central role.

KEY-WORDS: GOVERNANCE- COMPETENCE – LOCALIZED TECHNOLOGICAL KNOWLEDGE

JEL CLASSIFICATION CODE: D23 - O31 - O31.

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1. Introduction

Transaction costs economics has made it possible significant progress in the economic analysis of the firm. The continual process of implementation and redefinition of the original framework put forward by Ronald Coase and Oliver Williamson and the contributions of the resource-based theory of the firm have paved the way to a broader approach: the economics of governance.

In transaction costs economics the firm is viewed as a bundle of activities selected according to the relative costs of transaction and coordination. Inclusion is decided when the costs of using the markets are higher than the costs of coordinating internally the production. The basic choice is whether to buy a given component or other intermediary inputs or to make them. The decision is taken in a static context where coordination and transaction costs are given and depend upon exogenous factors. The role of competence and knowledge is not considered.

An alternative view of the firm has been elaborated by the resource-based theory of the firm. The resource-based theory of the firm has emerged as a consistent body of literature centred upon the key role of the firm in the accumulation and generation of technological knowledge and competence and its transformation into technological and organizational innovations (Penrose, 1959; Foss, 1997).

In the resource-based theory of the firm little attention is paid to understanding the role of coordination costs in limiting the size of the firm and to the constraints and opportunities of the market place as an alternative mechanism of governance.

The analysis of coordination and transaction specific activities cannot be conducted in isolation with respect to the choices and the characteristics of the production process and the markets for products and intermediary inputs. The decisions of inclusion and exclusion of each specific segment of the production process can be assessed only when coordination and transaction are viewed as the result of well specified forms of economic activity characterized by their own specific form of competence and organizational knowledge.

This makes it possible to move from transaction costs economics towards a broader economics of governance approach. The object of analysis in the economics of governance approach is the organization of the firm with a special emphasis upon the localized process of accumulation of technological and organizational knowledge and the introduction of both technological and organizational innovations.

The rest of the paper is structured as follows. In section 2 the comparative assessment of the elements of strength and weakness of transaction cost theory and of the resource based theory of the firm is elaborated as a step towards an integrated economics of governance. Section 3 discusses the interdependence between production, transaction and coordination and provides an analytical model, which is subsequently applied, in section 4, to grasp the complexities of interdependence in a dynamic context. The conclusions summarize the argument and put it in perspective.

2. Towards an economics of governance.

Two different approaches confront each other in the theory of the firm: transaction cost economics and the resource-based theory. A comparative analysis makes it possible to stress their relative

advantages as well as their weaknesses. In so doing it provides the elements to elaborate an integrated approach.

2.1. From transaction costs economics to the economics of governance.

Transaction cost economics is the result of an incremental process of extension and implementation of the framework first elaborated by Ronald Coase. Oliver Williamson provided an operational context which proved to be extremely fertile.

The unit of analysis here is the transaction. The firm is viewed as a nexus of contracts and a portfolio of given production functions which coexist within the same organization according to the trade-off between coordination and transaction costs. The choice whether to include or exclude a given production process within the borders of the firm depends upon the levels of coordination and transaction costs respectively. When the costs of internal coordination are higher than the costs of using the market, a transaction takes place and that production function remains outside the borders of the firm. Inclusion takes place when the costs of internal coordination are lower than the costs of using the market (Williamson, 1975, 1985, 1990, 1996).

The coordination of diverse activities entail specific costs associated with the need to control the actual performance of the tasks assigned to the agents and to monitor their efficiency. Coordination costs are specific information costs stemming from the bounded rationality and limited knowledge of managers (Simon, 1947, 1982; Alchian and Demsetz, 1972).

Transaction costs depend upon given technological features such as the asset specificity and the frequency of exchanges, the characteristics of the market place in terms of transparency,

common trust and actual enforcement conditions of obligations in contracts, hence institutional reliability. The levels of transaction costs mainly consist in the costs of the resources that are necessary to search for possible suppliers of specific components and activities, the assessment of their quality, price and delivery conditions, the costs of designing effective contracts with the perspective suppliers and to enforce them. Transaction costs as well are expression of bounded rationality and limited knowledge, but they concern the perspective external suppliers, rather than internal agents².

In transaction costs economics neither transaction or coordination are viewed as activities, but solely as costs: there is no analysis on the efficiency of the activities which are put in place in order to perform the required coordination and transaction. There is no analysis of the knowledge and the competence necessary to coordinate and use the markets respectively and hence little room is left to understanding the process of accumulation of new organizational knowledge and the introduction of organizational innovations. For the same token, the technology of the production process is considered as given and exogenous. In transaction costs economics the firm does not consider the issues of the choice among technologies and even less attention is paid to the governance of the accumulation of new knowledge and the introduction of new technologies. The interdependence between technological choices and organizational ones is not considered.

The poor attention paid by the transaction costs economics to the conditions and the dynamics of the accumulation and generation

² Much attention has been paid in institutional economics to assess the relationship between transaction costs economics and the incomplete contract theory (Grossman and Hart, 1986; Hart, 1995). Incomplete contract theory stresses the role of bounded rationality and the limitations of information impactedness in designing 'perfect' contracts and hence the need for internal coordination. Repeated renegotiations however can reduce the costs of the use of the markets. Upon these basis incomplete contract theory seems to be complementary to transaction costs economics rather than a substitute (Brousseau and Fares, 2000; Holmström and Roberts, 1998).

of new knowledge and competence is a major weakness. Knowledge and competence applied to the manufacturing processes as well as to the management of the internal coordination and to the procedures and the skills that are necessary to use the markets, are key to understanding the firm. A clear understanding to the role of technological and organizational knowledge in the theory of the firm is provided by the resource-based approach.

2.3. From the resource based theory of the firm to the economics of governance.

The resource-based theory provides a distinctive and yet complementary approach to analyzing the firm. The emphasis here is put on the process by means of which the firm is able to introduce technological and organizational innovations (Penrose, 1959). The firm is viewed as the locus where technological and organizational knowledge is generated by means of the integration of learning processes and formal research and development activities. The firm is considered in this approach primarily as a depository and a generator of competence (Foss, 1997 and 1998; Foss and Mahnke, 2000).

The resource-based theory of the firm has grown as a development and an application of the economics of learning. The enquiry about the dynamics and the characteristics of learning processes, such as learning by doing and learning by using, and their relevance in explaining technological change has led to the identification of the firm as the primary locus of the generation and valorization of knowledge immediately relevant for the economic action, at least in market economies (Arrow, 1962a; Lamberton, 1971; Loasby, 1999).

In the resource based theory of the firm, the generation of technological knowledge is regarded as the distinctive feature of the firm. The firm does not coincide with the production function and cannot be reduced to a production function because its essential role is the accumulation of competence, technological and organizational knowledge and the eventual introduction of technological and organizational innovations. From this viewpoint the firm precedes the production function: the technology is in fact the result of the accumulation of knowledge and its application to a specific economic activity. Technological knowledge can be considered the primary output of the firm and in turn an intermediary input. The choice whether to sell it or to use and make with it is especially relevant.

In the resource-based theory, the firm cannot be viewed as a nexus of contracts neither: the specificity of the production process and the characteristics of the products are a consequence of the process of generation of technological and organizational knowledge. Hence the firm, in the resource-based theory, is much more than a nexus of contracts: it is primarily a mechanism for the production of knowledge

The resource-based theory of the firm however has paid little attention to understanding the role of organizational factors in shaping the accumulation and generation of new knowledge. Specifically, the resource-based theory of the firm has not elaborated a full understanding of the constraints, in terms of both rate and direction, to the dynamics of learning, that arise from the costs of using the hierarchies and the markets respectively. Organizational factors shape the valorization of the knowledge accumulated by means of the learning processes and constrain the direction as well as the rate of learning.

The blending between the resource based theory of the firm and transaction cost economics into a fully articulated economics of governance seems a necessary step to appreciate the key role of localized technological and organizational knowledge in shaping the growth of the firm.

3. The governance system. A model of interdependence between production, transaction, coordination and knowledge generation

The integration between the transaction costs economics and the resource-based theory of the firm provides major opportunities for implementing a broader economics of governance. Important complementarities are found when an effort is made to understand the role of competence and knowledge in the definition of the borders of the firm, under the constraint of the resources that are necessary to coordinate the diverse activities retained within its borders. The generation of knowledge is the primary role of the firm but under the constraint of governance costs.

The integration of transaction costs economics and the resource-based theory is possible when attention is focused upon the interdependence between the decision making in the manufacturing activities and in the coordination and transaction ones. In such an approach competence is the basic factor in performing the full range of activities that are necessary to understand the firm. The understanding of the factors affecting the choice between inclusion and exclusion, including the costs of using respectively the markets and the internal hierarchies, is a basic ingredient in a theory of the firm which does not longer coincide with the textbook production function.

In the economics of governance the definition of the borders of the firm and the choice between exclusion and inclusion is the result

of a broad range of dynamic factors. The assessment of the inclusion/exclusion choice includes the efficiency of the internal manufacturing of the components with respect to their market prices, as well as the competence of the firm in performing transaction and coordination activities respectively. The characteristics of the process of accumulation of technological and organizational knowledge and of the endogenous introduction of new technologies and innovations in the governance activities that are necessary to perform transaction and coordination influence the inclusion/exclusion decision making, as well as all innovations in the production process.

Economics of governance benefits from the resource-based theory of the firm in expanding the scope of transaction costs economics so as to include the analysis of: a) the accumulation of competence and knowledge, b) of introduction and selection of technological and organizational innovations and c) their effects on the design of the portfolio of activities which are sorted to be respectively included within the firm and assigned to transactions in the market place (Penrose, 1959; Chandler, Hagstrom, and Solvell, 1998).

The understanding of the overlapping between production theory, economics of innovation and economics of knowledge makes it possible to provide an integrated analytical framework which is able to study the broad range of factor that affect the governance of the firm viewed not only as a nexus of contracts, but rather as a selective and selected combination of complementary activities based upon the capability to accumulate competence and knowledge.

In the economics of governance, the firm is a bundle of activities selected under the constraint of technological, organizational and market factors. Neither factor can be isolated: the actual size of the firm and its structure can be understood only when the three

classes of factors are analyzed in closed conjunction and an effort is made to appreciate their interdependence.

Specifically within the borders of the firm we can identify production activities, a coordination activity and a transaction activity. The implementation of all activities implies appropriate levels of knowledge and competence and hence of efficiency. The introduction of organizational innovations in coordination and transaction activities and of technological innovations in production, in turn leads to increasing their efficiency.

The coordination activity provides the management, monitoring and assessment of the relations between the indivisible modules that are retained within the borders of the corporation. The transaction activity consists in the use of the markets for the provision of intermediary inputs.

The borders of the firm are assessed according to the costs of intermediary products internally manufactured relatively to the costs of external inputs. The choice between the exclusion and the inclusion of each input is influenced by an array of factors that are strongly interdependent in assessing the size of the portfolio of activities performed within the borders of each firm. The understanding of such interdependence makes it possible an important progress in the theory of the firm.

Firms select the mix of internal and external products and services according to the combined costs of production and coordination on the one hand and the combined costs of purchasing and using the markets on the other. Coordination activities cannot be separated from the own internal manufacturing of the products and services. For the same token transaction activities cannot be separated from the actual use of the market as an alternative mean of procuring or selling some products.

In so doing some substitution takes place. Neither coordination or transaction activities however can be cancelled. A notion of partial substitutability between coordination and transaction activities emerges. The choice between coordination and transaction, and hence between inclusion and exclusion, can take place, but to a point. The traditional analysis of complementary substitutability between production factors, familiar to the theory of production, applies also to the analysis of the governance of firms. This notion of partial substitutability between coordination and transaction activities makes it possible to explore a wide range of mixed governance structures where varying mixes of transaction, production and coordination activities are at work. In doing the key role of localized technological and organizational knowledge can be fully appreciated.

The cost of internal inputs depends upon the sheer cost of the production process of each activity and the costs of their coordination. The cost of external inputs depends upon their market price and the costs of their procurement in using the markets³.

³ The closer are the market prices to the internal costs of manufacturing and the more relevant is the ratio of transaction costs to coordination costs in defining the borders of the firm and the size of the portfolio of activities which it is profitable to include into its borders. When the market prices differ from internal manufacturing costs there is a direct incentive to change the borders of the firm. Such a difference may depend upon a variety of factors. Two classes can be easily identified: external factors and internal ones. The former concerns the conditions of the market place; the latter the internal conditions of the manufacturing process. Imperfect market conditions in the supply of inputs and hence market prices that differ from the minimum average costs levels push either towards inclusion - when market prices are above minimum average costs- or towards exclusion when market prices for complementary products, often in the case of barriers to exit are below the minimum average costs levels. Internal factors in manufacturing matter as well in assessing the choice whether to include or exclude. Internal manufacturing costs may differ from market prices for a variety of factors that belong to the idiosyncratic characteristics of the firm. Idiosyncratic increasing returns can explain internal manufacturing costs that are lower than market prices. This is clearly the case when factors of indivisibility and irreversibility, specific to the history of each firm, lead to economies of scale, economies of density, economies of scope and agglomeration externalities. When increasing returns apply to a product, the firm has a powerful incentive to include its production process. Clearly with decreasing returns in the manufacturing of a specific product the firm has a strong incentive towards its exclusion.

These decisions however cannot be taken without a clear assessment of the costs associated with inclusion and exclusion respectively.

Both coordination and transaction are resource-consuming activities. Dedicated inputs are necessary to perform the coordination and transaction activities. The usual relationship between inputs and outputs applies. The efficiency of the coordination and transaction activities is determined by the competence accumulated and the organizational knowledge available to each firm. Higher levels of organizational competence may eventually lead to the introduction of organizational innovations which in turn make it possible to improve the efficiency of both the coordination and the transaction activities (Argyres, 1995).

Here the interdependence between the factors becomes evident. At each point in time, for given levels of competence in transacting, the adoption of a technology may be influenced by the levels of the transactions costs that are associated with the asset specificity and the frequency of the transactions that characterize it. With different levels of competence however the firm may select other rival technologies. In this approach the technology of each production process is the result of the innovative choice of the firm itself: the characteristics of each technology are not given and exogenous, but are the result of the innovation and the related accumulation of knowledge and competence within the firm itself. Here it seems clear that the conditions of the coordination and transaction activities affect directly the process of generation and use of technological knowledge and eventually the design and the specific introduction of the new technologies (Loasby, 1999; Teece, 2000; Nooteboom, 2000).

The blending of the transaction costs economics and the resource-based theory makes it possible to understand the constraints and the limitations that the costs of using the hierarchies and the markets respectively exert upon the accumulation and generation of new knowledge. The firm itself can be regarded as an island of coordination procedures that facilitate the accumulation of knowledge. The Coase-Williamson argument, much applied to the choice between coordination and transaction in the organization of the economic activity, can now be stretched and elaborated so as to understanding the fabric of technological knowledge (Furubotn, 2001).

3.1 The model

In standard microeconomics the firm coincides with the production function. In transaction costs economics, coordination and transaction costs define the borders of the firm, but no analysis is provided on the activities that are necessary to perform these functions, the role of competence and knowledge, both in the organization and in the production and their interdependence. In the resource-based theory of the firm, learning generates knowledge and knowledge makes growth possible, but little attention is paid to the constraints and limitations of organizational factors.

In the economics of governance, the output of each firm is the result of the combination between internal and external inputs, respectively manufactured, managed, selected, monitored and purchased by means of dedicated activities. Activities in turns are shaped and characterized in terms of competence and dynamic efficiency.

The firm is viewed as a micro-system where a plurality of interdependent learning activities are at work and influence each other. The governance choice is made according to the costs of external inputs and internal ones. These however are determined by the efficiency of the activities that are necessary to produce them.

The governance of the firm can be viewed as the selection of the combination between bundles of production and organizational activities, rather than goods: the selective procurement of external inputs and the production and coordination of internal ones⁴.

A simple governance system of five equations accommodates the analysis elaborated so far. The working of the firm can be grasped by means of a corporate function and a production function where standard substitution takes place and a transaction and coordination activity characterized by fixed coefficients. Each is qualified by the key role of knowledge and competence modelled with a shift parameter. A standard cost function completes the set of constraints that make it possible to analyze the behaviour of the firm. Formally we see the following:

- 1) $Y = A_1(t) ((TRA)^\alpha, (CO)^\beta)$
- 2) $TRA = (A_2)(t) (EXTERNAL, R)$
- 3) $CO = (A_3)(t) (INTERNAL, R)$
- 4) $INTERNAL = (A_4)(t) (K^a, L^b)$
- 5) $C = p EXTERNAL + u R + r K + w L$

Where Y denotes the output levels that are obtained by means of a corporate function characterized by a general level of competence $A_1(t)$ that can increase in time and provide the combination of

⁴ This model builds upon the basic intuition provided by Riordan and Williamson (1985), subsequently elaborated in Antonelli (1999b)

external inputs (EXTERNAL) that are either purchased in the market place by means of transaction activities (TRA), or by means of inputs that are manufactured internally –by means of a standard production function based upon capital (K) and labor (L) inputs as well as specific technological knowledge (A_4) which increases over time because of learning processes and dedicated research activities - and managed by means of coordination activities (CO).

Coordination activities are the product of the organizational resources (R) that perform the specific task of coordinating the inputs produced internally by means of the production function. Coordination activities moreover are characterized by some dedicated levels of competence and organizational knowledge (A_3) that is allowed to change over time because of learning and dedicated research activities. Transaction activities also are the output of organizational resources (R) that perform all the clerical tasks that are necessary to purchase in the market place the external inputs. Transaction activities in turn are characterized by specific and dedicated levels of competence and organizational knowledge (A_2) that changes over time because of learning processes and dedicated research activities.

For both activities, a fixed coefficient between the amount of respectively internal and external inputs and the organizational resources (R) that are necessary to perform the coordination and transaction activities is given. It may change over time according to the value of the specific shift parameter that measures the rates of accumulation of dedicated knowledge in each activity and to the informational conditions of hierarchies and markets⁵.

⁵ The quality of the markets varies according to their thickness: the number of players on both the demand and the supply sides. Industrial dynamics, in terms of rates of entry and exit, may impose additional burdens in terms of transaction costs even if it has positive effects in terms of the reduction of the market prices towards competitive levels. The better is the quality of the markets, from an informational viewpoint and the lower is the amount of search costs to identify the correct price and the reliable partners in trade. The levels of opportunism socially accepted and hence the levels of trust that are necessary to stay in the market place are clearly relevant. Institutions and norms hence enter into

The governance function can be characterized by returns to scale that can be increasing or decreasing according to the parameter α and β . The production function in turn can exhibit increasing or decreasing returns to scale according to the value of the parameters a and b .

Next to the governance function there is a general cost function where the costs of the external inputs that enter the transaction activities (p) and the unit costs (u) of the organizational resources (R) that enter both the transaction and coordination activities respectively are considered together with the unit cost of capital (r) and labor (w).

The working of the governance system is quite simple. For given market prices of the output, the firm will select not only the levels of output but also the portfolio of activities according to: i) the efficiency of the production process; ii) the effects of increasing returns in production; iii) the efficiency of the corporate function; iv) the effects of increasing returns in the corporate function; v) the efficiency in the transaction activities and vi) and the competence and hence efficiency in coordination activities.

The firm will rely more on external rather than internal inputs when the production function is characterized by a relative inefficiency with respect to other suppliers or when decreasing returns affect its average manufacturing costs, when coordination activities are less effective than transaction activities and hence coordination costs are larger than transaction costs.

the scene. The complexity and the novelty of the products and hence the amount of information that are necessary to assess their quality play a major role. Institutional and social conditions play a key role also in assessing the levels of coordination costs (Antonelli, 2003).

The details of the production process, such as the efficiency of the internal production process and the extent to which increasing and decreasing returns are at work, can be assessed with respect to the prices of the products in the markets. The levels of transaction costs, as determined by the dedicated competence of each firm in using the markets, interact both with the comparative costs of the products manufactured internally with respect to their market prices, and the levels of efficiency of the coordination function⁶.

The governance choices are made under the influence and the effects of all the factors that have been considered so far. The quality of the markets, both from an informational and a competitive viewpoint, the characteristics of the products and especially their novelty, the features of the production process both with respect to the levels of asset specificity and to the costs of production, the levels of technological advance in manufacturing, with respect to competitors, and the levels of competence in performing respectively coordination and transaction activities are interdependent factors which influence each other and which cannot be separated and isolated in assessing the governance choice of the firms.

4. The role of knowledge: dynamic implications

The model elaborated so far to handle the analysis of the interdependence between production, transaction and coordination

⁶ All changes in the external conditions of the markets can also be assessed. When the thickness of the markets increase as well as their informational transparency, transaction costs decline and hence the use of the markets become more effective: the borders of the firm shrink. From a comparative viewpoint the differences, across regions and industries, in the organization and in the size of the firms can be now viewed as determined by the differences in the thickness, transparency and competitiveness of the markets. Countries and industries where the average size of the firms is larger as well as the scope of their portfolio are likely to be characterized by lower levels of transparency. The size of firms is smaller as well as the levels of diversification in industrial districts typically characterized by high levels of trust and transparency, mainly because of a historic tradition of repeated interactions. Large diversified holding companies can be considered the end result of lower levels of informational quality of the markets for intermediary inputs. Firms may grow into large diversified companies however also when coordination competence is very high and it is rooted in the national and industrial traditions and institutions: as such it is difficult to swarm elsewhere.

activities, is a first result of the attempt to merge the transaction costs economics with the resource-based theory of the firm, still in a static context, yet it has many important dynamic implications.

The focus upon transaction and coordination viewed primarily as activities, which entail specific competencies and dedicated levels of organizational knowledge, rather than sheer costs, has in fact direct and relevant consequences in dynamic terms. Here the variety of firms and their localized endowment of competencies and experience built by means of learning processes matter.

The firm is no longer viewed as a representative agent. The specific characteristics of the firm need to be investigated and assessed both with respect to the organizational processes and with respect to the production processes. The analysis of production and organization cannot be separated.

The corporation is a resource pool designed and managed so as to implement the opportunities for the accumulation of both new technological and organizational knowledge. The rates of technological and organizational learning influence each other in shaping the dynamics of the firm, the evolving composition of the collection of activities that are retained within its borders and ultimately its growth (Chandler, Hagstrom, and Solvell, 1999; Teece, 2000).

The notions of localized technological knowledge and localized technological change stress the relevance of the learning processes circumscribed in the specific and idiosyncratic locations, within technical, organizational, product and geographical spaces, of each firm at each point in time. The learning processes in such locations are the basic conditions for the accumulation of experience and the eventual generation of both competence and tacit knowledge. On these bases in turn the firm is able to acquire

other forms of knowledge, respectively external codified and tacit knowledge and to implement the internal tacit knowledge with research and development activities. In this approach, the firm is primarily defined as a bundle of activities that are complementary with respect to the generation of knowledge and competence (Antonelli, 1999a and 2001).

The characteristics of the process of accumulation of competence, of the generation of technological knowledge and of the introduction of technological and organizational innovations, are key factors to understanding the firm. Parallel to knowledge, competence is a central ingredient. Competence is defined in terms of problem-solving capabilities and makes it possible for the firm not only to know-how, but also to know-where, to know-when, and to know what to produce, to sell, to buy. Competence and knowledge apply to the full set of activities: production activities, transaction activities and coordination activities (Nooteboom, 2000).

The dynamics of the firm is shaped by the dynamic interdependence among the accumulation of localized knowledge and competence respectively in coordination, transaction and production (Chandler, 1962, 1977, 1990).

The accumulation of experience and competence in the production process, out of learning processes, leads to more efficient production processes. The costs of the internal production are lower than the markets prices for the same goods even in competitive markets. The firm internalizes that production even if transaction costs are low and coordination costs are high: production costs matter and interact with the organizational decision making.

For the same token all learning in coordination is likely to increase the stock of dedicated organizational knowledge and hence to increase the efficiency of the firm in performing coordination activities. The larger is the competence in coordination, and the larger is the portfolio of activities, which can be retained within the borders of the firm. Firms grow into large diversified, integrated and possibly multinational corporations when coordination competencies are large.

The introduction of an array of innovations in coordination activities, such as the multidivisional form, the matrix structure and in-house outsourcing have made it possible to reduce coordination costs (Chandler, 1962, 1977, 1990; Bonazzi and Antonelli, 2003).

The introduction of major technological innovations, such as new information and communication technologies, has important implications in terms of organizational innovations. Information and communication technologies have made it possible to reduce the information asymmetries and hence coordination costs. Similar effects however have been observed in transaction costs: e-commerce and especially e-markets seem to make it possible relevant reductions in the costs of transactions (Antonelli, 1988).

Learning in transaction increases the competence of the firm in using the markets and hence to reduce the levels of transaction costs with the ultimate effects, *coeteris paribus*, to push the firm to reduce the number of activities retained within its borders. Firms, able to elaborate a distinctive competence in dealing with market transactions shrink the size of their portfolios of activities conducted internally but can extend the scope of their operation as intermediary (Spulber, 1999).

Decreasing returns in the corporate function can become a major obstacle for the firm to benefit from the accumulation of technological knowledge and prevent the successful introduction of technological innovations. Organization costs limit the growth of the firm, when it is based only upon the generation of technological knowledge –or increasing returns in manufacturing– that is not paralleled by the accumulation of organizational knowledge (Arrow, 1974).

Organization costs matter when there is a case of diffusion of new rival technologies and of technological variety at large. Here the selective adoption of a technology instead of another may be influenced by the levels of transaction costs in the market place. Transaction costs in other words influence the technology rather than being determined by the technology. For the same token coordination costs can affect technological choices.

In the governance economics context of analysis a new area of analysis emerges, one where the governance choice concerns also the markets for outputs, rather than the sole markets for inputs. The firm in fact considers not only the possibility to make or buy a specific component or stage of the production process, but also whether to sell its products in the intermediary markets or to the final ones. Needless to say the stages of the intermediary markets where to sell are also a matter of choice and assessment. The firm can decide whether to integrate and diversify downward, as well as upward. In this context the firm can also make the choice to sell and eventually to buy again at a later stage of the production process. Here the firm selects the stages of complex and interdependent production processes, which can be internalized, and the stages to externalize, but retains the control of the overall production process articulated in sequential steps. The market and the organization become interdependent. The firm can be at the same time the vendor of a product and the buyer at a later stage.

The firm can buy back the full amount of the goods produced with her own original inputs or only a part. The borders between the firm and the markets become more and more flexible and subject to continual redefinition.

The analysis developed so far has important applications to understanding the conduct of the innovative firm when the stock of technological knowledge accumulated within each firm and the competence built by means of learning processes and formal research and development activities is considered an output per se, rather than an input for the subsequent production of goods and services in the markets for technological knowledge. Now the choice between to make or to buy is integrated by the choice between to sell or to make. Specifically firms assess both whether to produce internally all the knowledge that is necessary for the introduction of new technology or purchase it in the markets for external knowledge, and whether to sell the knowledge in the markets for knowledge or to use it to make other products.

The use of the market place to exchange technological knowledge is more and more common. Technological knowledge can be fully generated internally or partly purchased in the markets for knowledge: external knowledge can be an intermediary input for the production of other knowledge⁷.

Technological knowledge can be sold with varying levels of embodiment into other goods and services. Technological knowledge can be sold as an intangible good, more or less associated with other services such as the assistance of the vendors to the customers. Technological knowledge can be sold embodied at an early stage of a broader production process, or embodied in products that are manufactured at other stages farther down in the

⁷ See Antonelli, Marchionatti and Usai (2003) for an empirical estimate of the role of external knowledge.

general production process leading to the products actually purchased by the final consumer: the household (Guilhon, 2001; Arora, Fosfuri, and Gambardella, 2001).

Knowledge transaction costs, i.e. the costs for using the markets for knowledge play a key role in this context. In turn, knowledge transaction costs are affected by the characteristics of knowledge, such as appropriability, cumulability, complementarity, fungibility and stickiness. Knowledge transaction costs play a major role to understand the architectural design of the firm and the combination of activities retained within its borders. Let us analyze them in turn (Arrow, 1962b and 1969).

With low levels of knowledge appropriability and hence high risks of opportunism and dissipation of the rents associated with knowledge, knowledge transaction costs are very high and firms cannot rely on the market place to valorize their intangible outputs. The embodiment of technological knowledge into new products and their eventual sale in the market place becomes necessary (Teece, 1985, 2000; Antonelli, 2001).

The quasi-private good nature of technological knowledge as a matter of fact does not necessarily leads to undersupply but rather pushes the knowledge-creating firm to use it as an intermediary input for the sequential production of economic goods. Downstream vertical integration is the remedy to the problems raised by the non-appropriability and low tradability of knowledge as an economic good⁸. The generation of appropriate quantities of knowledge can be stimulated by the opportunities in the markets for the products that are manufactured and delivered by means of the technological knowledge they embody.

⁸ This result is important as it contrast the traditional argument about the failure of markets, as a coordination system, in the allocation of resources to the production of knowledge because of the lack of incentives stemming from low appropriability and the related 'knowledge as a public good' tradition of analysis (Antonelli, 2004).

When technological knowledge can be easily appropriated by the innovator, either because of its complexity and hence natural levels of high appropriability, or because the regime of intellectual property rights is effective and easily enforced, knowledge transaction costs are low and, for given levels of internal coordination costs, firms prefer to sell directly the technological knowledge as a good per se in the markets for knowledge. Transaction costs in the markets for knowledge are lower than the costs of the internal coordination of the production of the product that embody that technological knowledge (Antonelli, 2004).

Knowledge fungibility is defined by the variety of production activities to which the same unit of knowledge can be successfully applied. With given knowledge transaction costs firms, able to introduce technological innovations with high levels of fungibility, are likely to be larger and more diversified and integrated. Strong increasing returns take place in the usage of the same stock of technological knowledge and can counterbalance the increase in average coordination and manufacturing costs⁹.

When technological knowledge is characterized by high levels of cumulability, so that the generation of each new unit of knowledge relies upon the localized accumulation of technological knowledge, dynamic coordination and transaction costs emerge. Dynamic transaction and coordination costs are defined in terms of opportunity costs of the governance of the stock of knowledge with respect to the stream of generation of new knowledge.

Inclusion now yields the opportunity to appropriate the eventual benefits stemming from the accumulation of knowledge in terms of higher opportunities for the introduction of additional units of knowledge. Exclusion and transaction instead yields new costs in

⁹ The welfare losses stemming from high knowledge transaction costs and hence high levels of vertical integration in the case of high levels of knowledge fungibility are high because the application of each bit of fungible knowledge to other activities is limited by the embodiment in a firm active in a narrow range of products.

terms of the missing opportunities to benefit from the cumulative learning processes associated with the production process itself. Firms select inclusion and exclusion not only with respect to the static assessment of coordination, transaction and production costs for a given product and a given technology, but also and mainly with respect to the technological opportunities that are associated with the learning processes (Antonelli, 2003).

Knowledge transaction costs matter also on the demand side. Important resources can become necessary in order to search, identify and purchase the bits of external knowledge that are necessary for the generation of new knowledge. Knowledge transaction costs are especially relevant when technological knowledge is characterized by high levels of complexity: each new bit of knowledge is the result of the recombination of many different elements. Knowledge transaction costs affect here the choice between making all the diverse bits of knowledge or purchasing them in the markets for technological knowledge. Intellectual property rights here can perform the essential informational role of signalling, spreading the information that the knowledge corresponding to a patent exists and can be acquired¹⁰.

Knowledge stickiness is found when it is difficult to separate the knowledge, often tacit, from the human capital and the organizational routines of the unit where learning activities have been taking place and the knowledge has been generated. In this case an issue of indivisibility emerges. Financial markets and more generally the markets for property rights provide an opportunity for a firm that cannot exploit directly the new knowledge because of steep organization costs curves. The incorporation of the unit into a new corporation and its sale in the

¹⁰ The design of an intellectual property regime that makes it possible the application of the liability rule and hence the reduction of the exclusivity of ownership combined with the full valorization of the informational role of patents can help reducing knowledge transaction costs.

financial market becomes a viable solution. Here technological knowledge is embodied in the corporate structure.

This analysis leads to yet another dynamic aspect of the model considered concerning the economics of knowledge spillover. Firms cannot include the full range of activities engendered by their learning processes in manufacturing because of the limitations of organizational factors. A selection process takes place. The decision of inclusion takes into account both the profitability of the incremental activity and its organizational costs. With a positive slope of unit organizational costs, the inclusion of new activities can be rejected because of their high marginal organization costs, even if their profitability is above average levels. This paves the way to a new approach to knowledge spillover.

Knowledge spills from firms not only because of low appropriability, but also because of high internal selection standards, imposed by organizational costs. The larger are the firms and the larger the spillover is likely to be: large firms are likely to have higher levels of coordination costs. Spillovers are likely to be larger, the lower the market tradability of the knowledge. When knowledge tradability is higher in fact firms will be able to try and sell the marginal knowledge in the market place. When knowledge tradability is low and yet inclusion cannot take place because of coordination costs, firms are not able to take advantage of such technological opportunities. Such technological knowledge is then likely to 'spill' in the atmosphere and other firms, especially spin-offs, can take advantage of it.

The analysis of the interdependence between the laws of accumulation of competence and knowledge, their effects of the production process and the organization of the bundle of activities retained within the borders of the firm, makes it clear that at each

point in time an equilibrium point between contrasting forces can be identified. Yet the understanding of the dynamics of the learning processes, which constitute the essence of the firm, and their effects in terms of the introduction of competence, knowledge and innovations, makes it clear that an equilibrium point is nothing more than a step into a path of continual transformation.

All differences in the localized rates of learning, accumulation of knowledge and competence, across the different modules and activities retained within the firm, and with respect to other agents in the market place, are likely to change its borders and the architecture of the organization. At the same time it is now clear how the rates of accumulation of localized knowledge in coordination and transaction have a direct bearing on the actual possibility of each firm to benefit from the accumulation of technological knowledge and to generate successful technological innovations. From this viewpoint, technological change is localized by the interplay between dynamics of technological learning and the dynamics of organizational learning

5. Conclusion

Transaction costs economics and the resource-based theory have contributed along parallel lines of enquiry on the nature of the firm. In the resource-based theory, the firm is viewed as a bundle of activities defined by their complementarity with respect to the generation of new knowledge and competence. In transaction costs economics, the firm is also a bundle of activities defined by given and exogenous costs of coordination and transaction. The merging of these research programs into a broader economics of governance is fruitful from many viewpoints.

The integration of the dynamics of accumulation of localized technological knowledge and the dynamics of the introduction of technological and organizational innovations is a necessary step towards a more articulated theory of the firm. The essential understanding of the basic trade-off between inclusion and exclusion, elaborated along the lines set forth by Ronald Coase and developed systematically by Oliver Williamson can be further implemented in a more dynamical context.

The approach to the firm as a bundle of interdependent activities, where the generation of knowledge, production, coordination and transaction are complementary aspects of a broader process of governance can be developed into an dynamical framework where the firm is viewed as bundle of activities characterized by localized learning. Such an approach yields useful outcomes in terms of the systemic understanding of the interdependence and reciprocal feedbacks between different and yet complementary aspects of the decision making within the firm.

The economics of governance approach makes it possible to integrate the effects of the internal attributes of the firm in terms of generation of coordination and transaction competence with the understanding of the external conditions of the markets both from a competitive and an informational viewpoint. Finally the understanding of the characteristics of technological knowledge and its generation process in terms of levels of appropriability, tradability, fungibility and complexity can be operationalized and integrated into a broader context.

The integration of the transaction costs economics with the resource-based theory of the firm seems able to appreciate the variety of constraints and incentives, provided by the complexity of the organization and the market place, which shapes the working of the firm, viewed as the basic engine for the generation

of knowledge immediately relevant for economic action in a market economy.

The economics of governance makes it possible to better understand the role of localized knowledge in the activities of coordination, transaction and production. In so doing it marks a progress with respect to transaction costs economics, where both technological and organizational knowledge are exogenous and given. The governance economics approach however makes it possible to better grasp the effects of the interactions between organizational and technological knowledge and the constraints raised by organizational factors such as coordination and transaction costs in shaping the process of accumulation and generation of new knowledge. In so doing the economics of governance makes it possible a step forward with respect to the resource-based theory of the firm.

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