Abstract

If progressive de-integration of firms can be interpreted in terms of relative variations in transaction and production costs, specialization, and structural and strategic heterogeneity do not. In order to analyse the characteristics and the mechanisms that ground firms’ concentration on both specific technological contexts and particular functions along the value chain, the processes of management and generation of knowledge have to be taken into account. Throughout this work, we will stress as the choice to specialize derives from the decision on management of learning processes enabled by the interaction between the agents who compose the organizational structure. The approach followed is that of defining the firms’ structure based on cognitive capabilities that the organizational design can express. Agents’ rationality is bounded and operational environment is instable. Strategies of coordination within the firm have the passive role they are traditionally known for, but they will also have an active role: the decisions on coordination determine the typology of the learning processes enabled by the firm. We will show that: generally, the strategic choice depends on agents’ characteristics; the maintenance of the efficiency of the processes of management and development of knowledge calls for specialization. This work allows us to characterise the firms’ (structural and strategic) heterogeneity, and to stress the mechanisms that lead to their progressive (technological and functional) specialization.

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Introduction

The process of progressive de-integration and the tendency towards specialization of firms observed in the last decades have deeply changed the structure of productive system of the industrialised countries. They also represent one of the most interesting issues for firm theory (Hamel e Prahalad, 1990). Firms have tended to concentrate their activities on particular functions and technologies, showing, at the same time, a tendency towards an increasing differentiation in structural and strategic characteristics depending on both the typology of function carried out along the value chain and the technological context in which they operate. Then, progressive specialization and firms’ increasing heterogeneity can be considered as connected phenomena. They raise the question on why firms differentiate and specialise themselves along the double dimension of functions and technological ambit. The aim of this work is proposing a scheme that allows the characterisation of the determinants of this choice, and the definition of its dynamics.

If de-integration can be interpreted as a change in the relative rapport between production and transaction costs, the make or buy dialectic does not allow a satisfactory explanation and analysis of the determinants of specialization process. De-integration represents a dimensional change that is coherent with the determination of the firms’ boundaries in terms of comparison between transactions and production costs. Instead, specialization is a qualitative phenomenon whose analysis imposes to take into account the process of management and development of the knowledge utilised by firms to carry out their activities. Indeed, the process of specialization have manifested itself as a reaction to the raise in the importance of both innovative capabilities and product differentiation within the competitive strategies of firms, which are in turn increasingly less oriented towards price competition. Such variation in the strategies has lead to a rise in the complexity of production and commercialization of products and services. In this context, firms’ competitive resources are not only referable to the capability of the form of governance to maintain the allocative efficiency, but also to the capabilities and competencies the firm owns, and to the most efficient organizational design in managing and developing them (Stalk et al., 1996).

Within the approaches of transaction cost economy (Williamson 1975, 1985; Radner, 1992; Menard, 1994; Furubotn, 2001), property rights (Alchian and Demsetz, 1972; Grossman and Hart, 1986; Hart and Moore, 1990; Hart, 1995) and incentive system (Jensen and Meckling, 1976; Tirole, 1988; Holmstrom and Tirole, 1991; Holmstrom, 1999), the organizational coordination is aimed at managing the inefficiencies produced by contract incompleteness. Firm is a structure within which the flow of information is utilised to reduce the impact of informative asymmetries coming from the impossibility to complete contracts. Governance, control, and incentive systems are implicitly aimed at allowing the maintenance of the allocative efficiency in an environment characterised by asymmetrical information. The mechanisms of reduction of such asymmetries, which are proposed within those formulations, seem to be referable to a passive approach towards governance, that is, towards both the reduction of perverse behaviours and the management of potential conflicts. The relationship that links agents to the structure which coordinate them is univocal (their characteristics do not affect the organizational structure) and static (there is not a relation that links the developments of agents’ characteristics to the typology of
coordination). This is essentially linked to the hypothesis of full rationality – or to a not complete development of the bounded rationality hypothesis, such as the case of transaction costs economy – which eliminates the agents’ heterogeneity and overshadows the learning processes, which, instead, ground the development of their cognitive characteristics.

Within the formulations that utilise the full rationality hypothesis, cognitive resources are not definable, as well as the learning processes that allow their development are not taken into account (Holmstrom e Tirole, 1989). On the other hand, the inexistence of a relationship that links firm’s cognitive characteristics to the form of coordination prevents the analysis of the role of coordination in managing and developing resources. Stating an active relation between the structure of governance and agents’ characteristics is an essential condition in order to allow the emergence of the dependence between the two dimensions (structural and strategic) of heterogeneity. They will be defined in terms of knowledge, in order to express them based on the same logic unit of measurement. The relation that links the strategies of coordination to the characterisation of the firms’ organizational structure will be also stressed.

Throughout this work, firms’ efficiency will not be merely linked to factors and production allocation. The efficiency of the learning processes, which allow the firm to operate in an instable environment, will be also considered a goal. In such context, firm is a structure within which the flow of information is also utilised to manage and develop the knowledge. Knowledge is needed to decide (Simon, 2000), and it is acquired by means of the interaction between agents’ heterogeneities. Their characteristics will represent the characterisation of the structure, while the coordination, and the design of relationships between them, will represent the strategic dimension of heterogeneity. Based on such characterisation of heterogeneity, we will see that firms’ strategic choice will lead to a process of specialization whose necessity comes from the goal of maintaining the efficiency of learning and communication processes.

From a theoretical point of view, we will follow the approach of the theories that in Gibbons (2005) have been defined as «adaptation theories». In particular, resource-based (Penrose, 1959; Barney, 1992, 1996), evolutionary (Nelson and Winter, 1982, 2002), and knowledge-based (Kogut and Zander, 1992, 1996; Nonaka, 1994; Conner and Prahalad, 1996) traditions will be widely utilised throughout the development of the logical scheme of the work. These theories, as also claimed by other authors (Williamson, 2001; Menard, 2005; Garrouste e Saussier, 2005), have in common the assumptive frame, which is characterised by bounded rationality and presence of systemic instability, and the aim of analysing firms’ dynamical processes. Particularly, the evolutionary dynamics related to dimension (Penrose, 1959), technology (Dosi, 1982, 1988; Dosi et al., 1988; Teece, 1996; Kogut and Zander, 1992, 1996; Fagerberg et al, 2006), and organizational structure (March and Simon, 1958; Cyert and March, 1963; Nelson and Winter, 1982, 2002; Conner and Prahalad, 1996) are widely analysed through formulations that carve out an important role for the mechanisms of management and development of firms’ capabilities (resources).
1. From individual to collective action: the coordination

Starting from Coase’s work of 1937, the debate on firm theory can be considered as an implicit dialectic on coordination. Indeed, firm is alternative to market as the lieu of economic transactions. Firms’ organizational structure manages the transactions that are not efficiently coordinated by market mechanisms. Incompleteness of contracts does not allow the agents to complete the definition of the decisional context, thus generating the premise for the existence of the informative asymmetries that reduce the efficiency of the exchanges. Then, transaction costs assign a role to firms and justify their existence.

The coordination of economic transactions has two roles: supplying the information about the decisional context, and limiting the room for perverse behaviours. In the case of market, relative prices represent the agents’ informative set, while the constraint for behaviours is determined by the concurrent working of Pareto’s principle and full rationality hypothesis. In the ambit of bounded rationality and systemic instability, the information supplied by relative prices does not exhaust the description of the decisional context, while the behaviours are not efficiently coordinated by market mechanisms.

In the case of firm, coordination of economical exchange has to go with the coordination of the relationships that are produced within the organizational structure. The definition of the context does not refer only to the description of transactions, but it as to be referred also to the definition of relationships. Behavioural dimension of coordination also includes the management of the learning processes. Indeed, organizations have the characteristic to build a relational scheme substantially different from that built by market mechanisms. Market relationships are «spontaneous», while those within organizations are structured, and they have then to be defined and managed.

Within the transaction costs economy, governance has the role of supplying the behavioural rules and the information needed for reducing the risk for opportunism that derive from the incompleteness of contracts (Williamson, 1975, 1985, 2001). Here, efficiency of transactions is determined by the capability of governance to mitigate the effects of bounded rationality. In this formulation, governance of transactions has a passive role with respect to the relationships between agents. Coordination acts only as a device of reduction of the impact of potential perverse behaviours, while it does not seem to have any influence on agents’ learning, or on acquisition and processing of information. On the other hand, the definition of agents’ relational context is limited to the derivation of a hierarchical scheme without proposing a characterisation of the processes enabled within. There is not relationship that links the typology of the form of governance to agents’ characteristics: only the features of assets affect the organizational design. From this point of view, therefore, the Williamson’s work is not far, the hypothesis of bounded rationality notwithstanding, from the formulations proposed by property rights and incentive systems theories.

The lack of a perspective that grants an active role to governance depends on the absence of the analysis of the knowledge exchange that characterises the firm. Thus, learning processes, and the particular role that relations between agents have within the organizational structure in managing and producing knowledge, are not taken into account. However, the use of bounded rationality hypothesis would impose to taken them into account, because, in that context, the logic superposition between information and knowledge is not possible. This involves the need for some learning process aimed at translating information into knowledge. Furthermore, these learning processes must
have, in the case of a structure of relations such as the firm, a collective dimension. Indeed, despite learning is firstly an individual process, organizational coordination should have the role to translate it into a collective dimension.

In this ambit, management and contextualization of the relationships between agents represents an element of governance. Organizational coordination actively affects the design of relations, influencing both the expression of the single agent’s capabilities and the design of the connections between them. Here, the definition of a shared cognitive context, which grounds the agents’ communication, completes the definition of the operational context.

Under the hypothesis of bounded rationality, therefore, coordination of relationships involves the definition of a shared cognitive context that, once the agents’ heterogeneity is taken into account, would allow the communication and the sharing of representations. Indeed, according to Giddens (1991), institutions (firms) would supply agents with the contextual basis for their actions, that is, it would define the cognitive context within which agents can interact.

Thus, behaviours are contextualised within a scheme of interaction aimed at achieving firm’s goals. The typology of the relational coordination depends on the rigidity or rather flexibility granted to the structure of relations themselves. This depends, in turn, on whether elements of homogeneity or rather heterogeneity expressed by agents have to be privileged (Perroux, 1950). Alternatively, organization can be seen as a «system of roles», whereas the interaction that is produced between them is managed in terms of flexibility or rather rigidity of connections (Simon, 1991). In this context, organizational coordination is a device aimed at making coherent the individual and the collective dimension of action, from both the behavioural and the relational and cognitive point of view. The study of the relation between single agents and organization cannot be let aside from the analysis of the organizational structure. Those two elements interact and interfere each other.

The rapport between structure and agents – between context and behaviours in the Hodgson’s (1998) terminology – has to be studied in terms of a co-evolution and not yet as a unidirectional movement. Organizational coordination, in fact, not only affects behaviours in a passive manner, but also it actively affects their development. On the other hand, agents’ characteristics determine the typology of the structure of interactions. This relation of mutual interference between decisions on the structural form of coordination and the agents’ characteristics is the basis of the development of this work.

The rules of behaviour and interaction, which are expressed by organizational coordination, are the element that links the individual and the collective dimensions of the action. In this context, routines represent the collective capabilities (Dosi, Nelson and Winter, 2000), but also they implicitly define the cognitive and interactive basis of the firm’s working. The routine is, according to Giddens (1987), a psychological element implicit in the human reasoning that has the role of coordinating the unconscious and the action. In other words, then, it represents a conscious control that represents a filter between the individuals’ intrinsic characteristics and their behavioural manifestation. Nelson and Winter (1982) proposed an organizational application of the routine, following in part the path traced by Simon (1947), March and Simon (1958), Cyert and March (1963) with respect to the behavioural valence of the organizational coordination (Egidi and Rizzello, 2003).
Indeed, routine can be interpreted as a sequence of operational instructions aimed at coordinating the actions of the agents who operate in the same context. Cohen and Levinthal (1990) pointed out a cognitive characterisation of routine, interpreting it as an organizational patrimony and as a cognitive basis for the development of firm’s capabilities and competencies. This interpretation has been put forward again in an evolutionary fashion by Hodgson and Knudsen (2005, 2006), who define routines as the firm’s genotype, that is, as the knowledge basis through which firm’s capabilities can be developed.

Thus, routines would have both a behavioural and a cognitive dimension. This latter, affecting capabilities and relational possibilities, implicitly influences the structure of interaction. Then, routines take also a relational dimension, because their structure affects the design of relationships and its characteristics in terms of possibility and typology of interactions. The definition of the rules of interaction is an essential element in the determination of the communication structure. They allow the specification of the intensity of the informational exchange, and that of the sharing of knowledge that derives from the rapport between agents within the organizational structure. Intensity of relationships affects the «learning by interacting» processes that are enabled within the firm. Routines, once interpreted in those two dimensions, complete the spectrum of the roles assigned to coordination. Indeed, they supply the contextualization of the action and the structure that allow the interaction between agents.

2. The structure and the design of coordination

The agents’ characteristics and the relation that are established based on the organizational design represent the structure of the firm. The decision on the operational and interactive rules has to be interpreted as the process of coordination design. The emersion of the coordination design starts from the dependent labour contract, which states the participation of the agents in the organization. Particularly, starting from the existence of some coherence between the agents’ and firm’s goals (coherence of the satisfaction curves), we step to the determination of the rules (contract) through which a first form of coordination is achieved. Such step allows the characterisation of the firm’s structure, that is, it defines the number, the characteristics, and the position within the structure, of the agents. Once given our starting hypotheses, on the other hand, the contract will be incomplete. Then, there will be a residual area whose necessities for coordination do not depend on the elements inserted in the contract. This call for the determination of organizational rules whose design completes the needs for coordination.

Dependent labour contract involves that employee accepts the authority of employer (firm) within the space of possibilities. The area of acceptance of authority is defined as «the space coherent with reciprocal positive degrees of satisfaction of agents and firm within the space wage-action required» (Simon, 1951: p. 295). Furthermore, such area represents the definition of a shared context, that is, the necessary condition for the contextualization of the rules, which allows the specification of the structure achieved by means of the contract. The formalization of the contract provides the set of contractually determined elements and, implicitly, also the residual (contingent) ones, which are left to organizational coordination.

Following Simon’s (1951: p. 295) formulation, we can define $S_I(x,w)$ and $S_L(x,w)$ the satisfaction functions respectively referred to firm and workers. The trend of such functions represents the locus in which contractors’ satisfaction is zero. Supposing that
wage affects positively the worker’s satisfaction and negatively that of firm (Simon, 1951; p. 296), they can be depicted as in figure 1.

Generally, we will suppose that the level of the wage will be always coherent with the level of minimal satisfaction, or better that the analysis can be limited to the variations in the space of possibilities of the actions to be done. We can define \( x_0 \) and \( x_1 \) the extremis that border the space of \( X \in [x_0, x_1] \). The area \( A(X, w) = 1 \) of acceptance of authority will be determined by the space of the possibilities encompassed within the segment \( X \).

![Figure 1](image-url)

The existence of the area of acceptance of authority – that is, the existence of a non empty set that defines the space of contractors’ reciprocal positive satisfaction— is a necessary condition for contract to be signed. The contract will provide the specification of hierarchical relations and the contractually determined elements. Indeed, despite the impossibility to complete the contract, it is reasonable to suppose that firm and workers decide to insert a series of contingencies contractually defined. If some contractual element appears sufficiently stable, both contractors will have the incentive to determine it ex-ante, instead than to manage it ex-post.

The determination of fixed elements defined within the dependent labour contract will produce a narrowing in the space of possibilities, that is, the derivation of a segment \( B \subseteq X \) whose extremes \( b_0 \in b_1 \) border the space of the actions \( x \in B \) that firm can claim to its workers for, once the elements contractually fixed are specified. Therefore, the more the specification of contingencies is, the less will be the space of residual discretion left to both firm and workers in the decision on the action to be done. Once defined \( 0 \leq \sigma(B) \leq 1 \) (increasing in \( B \)) as a transformation function of the variation in \( B \) into variation in the area of acceptance of authority, we will obtain \( T(B, w) = \sigma(B)A(X, w) \leq 1 \), that is, the narrowing in the space of possibilities illustrated in figure 2.
Within the space $T(B,w)$ of possibilities, which will be defined area of governance, the coordination of actions is achieved by means of the design of routines. Within this area, firm will provide organization and management of operational procedures, and relations between agents. Design of routines determines the flexibility/rigidity of the rules, both operational – procedures and instructions – and relational – intensity of the information exchange and connection along the hierarchical chain. Generally, a rigid design will produce a set of binding rules that tends to narrow the space of possibilities. Indeed, the production of rigid rules works as a specification of contractually fixed elements, allowing higher control, but at the same time, reducing the possibility for actions coherent with the established area of coordination. The determination of flexible procedures, conversely, will produce the maintenance of a wider area of coordination of the actions even if it will reduce the possibility for control.

The degree of rigidity of routines will tend to reduce the width of the segment $B$. Segment $C \leq B$, whose extremis $c_0$ and $c_1$ border the space of the achievable $x$, will determine the amplitude of the further restriction in the space of possibilities. Once defined $0 \leq \pi(C) \leq 1$ (increasing in $C$) as the transformation function of the variation in $C$ into variation in the area of governance, we will obtain $R(C,w) = \sigma(B)\pi(C) \leq 1$, that is, the final status of the space of possibilities shown in figure 3. From now on, we will refer to the degree of flexibility of the design of routines as $R$. 

![Figure 2](image1.png)

![Figure 3](image2.png)
3. Cognitive definition of the dimensions of heterogeneity

From a perspective of a cognitive approach, firm has the also aim to manage and produce knowledge. Collective learning processes are enabled by the interaction between the agents who compose the organizational structure. Relationships and sharing are allowed by the design of coordination that provides the interactive rules and a code of communication that allows agents to exchange information within a common symbolic context. The substantial difference between the coordination provided by market and that provided by organization resides in the capability of the latter to supply agents with a structured and shared communicative context. Coordination of individual capabilities, which is provided by firms, allows the production of «scale economies of cognitive scope» that are not achievable my means of market (Nooteboom, 1992; 2000b). This comes from the fact that interaction between agents allows the enabling of «learning by interacting» processes (Lundvall, 1985), which permit the generation of a wider amount of knowledge with respect to the individual processes allowed by the type of informative and communicative scheme provided by market.

Generally, firms’ cognitive capabilities have an individual dimension, which refers to single agents’ characteristics, and a collective one, which refers instead to the cognitive potentialities contained within the relationships between them. In order to define these magnitudes, which represent the structural and the strategic dimension of heterogeneity in cognitive terms, we need a unit of measurement. It has to be able to represent both the capabilities to acquire, and interpret information, and those to communicate it. This result can be achieved by means of the concept of cognitive distance (Nooteboom, 1992, 1999, 2000a, 2000b).

Cognitive distance is a measure of proximity determined by the level of homogeneity/heterogeneity of the cognitive capabilities of two or more agents that relate each other. Generally, agents cognitively distant will have different representations of the reality and different communicative symbologie. The opposite will happen in the case of cognitive proximity. Then, agents with different knowledge bases will be able to acquire heterogeneous informative signals and, consequently, to work on a wider informative basis. The same heterogeneity will allow for a more complete interpretation. However, the process of interpretation calls for communication. This latter permits the sharing of representations and the step from the individual dimension of learning to the collective one. The communication will be generally more inefficient as long as the cognitive distance increases. Symmetrically, agents characterised by cognitive proximity will have better communication, but the informative basis of their actions will be narrower and their interpretation less complete.

Therefore, if knowledge derives from the processing of information (Hayek, 1952), or better, from the process of acquisition, interpretation and communication of the informative signals, cognitive distance can represent an interesting instrument. Indeed, it allows the determination of the capability to process information of a network of relations based on its dimension, through which is possible to trace back: the amplitude of the informative set on the basis of which the decision is done; the knowledge basis that grounds the interpretation of signals; the efficiency of the communicative process.

An element that emerges from the definition of cognitive distance is the presence of a trade-off between acquisition and interpretation, on one hand, and communication of information on the other. This involves the existence of a limit in the heterogeneity that the structure of relations is able to support. This means that a level of cognitive distance exists that involves incomunicability. On the other hand, complete homogeneity
would not allow the acquisition of relevant signals, thus maintaining the collective interpretation equal to the sum of those achievable by the single agents, that is, it reduces implicitly the efficiency of the learning process enabled by the interactions.

Based on the cognitive distance is possible to define the firm’s structure and the consequences of the coordination design on firm’s cognitive potential. The acceptance of firm’s authority by the workers allows the emergence of the organizational design. The hierarchical structure is a network of agents, who relate each other within. The building up of the firm’s structure allows the definition of agents’ cognitive characteristics, and the determination of the potential heterogeneity that characterise them. Such potential heterogeneity, which is just based on agents’ number and characteristics, is measured through the cognitive distance that will be defined potential, because it refers to a structure of relationships on which the process of organizational coordination is not yet completed. The structure, therefore, represents the potential the firm owns to generate knowledge, that is, the cognitive capabilities the firm has to manage through the coordination design.

Design of routines has been defined as the element that guarantees the organizational coordination within the firm. It determines the operational rules, which define the context, the range of discretion of the actions (space of possibilities), and the intensity of the relations that link the agents, which determines the level of heterogeneity they can express. The decision on the flexibility/rigidity of the design of routines, therefore, allows the management of the stock of cognitive capabilities. The determination of the space of possibilities, acting at the level of the single agent, affects the context in which he/she operates, implicitly defining the expression permitted to his/her cognitive capabilities and, consequently, the amplitude of the informative space from which he/she is motivated to acquire information. Indeed, agents’ knowledge basis (competencies/capabilities) expresses his/her absorptive capacity (Cohen and Levinthal, 1990), that is, the degree in which he/she is able to absorb information from the environment. A rigid operational context imposes a reduction in the utilisation of such capabilities and, consequently, a decrease in the acquisition of informative signals.

On the other hand, from a collective perspective, the determination of the intensity of relationships works as a constraint to the interaction between heterogeneities, that is, to the process of interpretation and communication of information. This imposes an organizational process that aims at privileging the elements of homogeneity between agents. Indeed, the process of generation of knowledge is affected by the interactive possibilities left to agents, those depending on the informative differential that exists between them. In order to enable the exchange of information that produces the processing processes, the maintenance of a certain degree of heterogeneity between agents is needed: they have to be able to exchange each other relevant (different) information. In other words, the coordination design determines the degree of heterogeneity that is covered at the level of both the single agent’s space of discretion and the intensity of relationships. It acts on both the process of acquisition of information (on the single agent) and in that of its interpretation and communication (on interactions).

Finally, the structure defines the potential capabilities the firm can expresses. On the other hand, the strategy determines the coordination design and affects the degree of utilisation of such capabilities.
4. Management and development of cognitive capabilities

The level of representation of the external environment owned by agents determines the decision (Simon, 2000). In such context, enlarging the cognitive basis of actions is the firms’ goal. Thus, generation of knowledge can be interpreted as a production process of the firm, while the capabilities to manage the flow of knowledge represents the firms’ distinctive feature with respect to market transactions (Conner, 1991). Cognitive capabilities that organization is able to express are the input of the knowledge production process. Under the hypothesis of full rationality, being information and knowledge conceptually superimposed, the achievement of a certain level of information implicitly represents the acquisition of the same level of knowledge. In this context, the information is scarce and costly goods, whereas the eventual limitation in the achievable knowledge derives from a choice made by the agent, who can consider acquiring new information as not convenient, and not any more from the limits imposed to humans’ processing capabilities (Radner, 1992). A stock of information is however freely available (Arrow, 1962), so as the exchange can happen, though with a second best type level of efficiency, which is determined by the incomplete definition of the decisional context (incompleteness of contracts) and/or by the presence of informative asymmetries (when the incompleteness of contracts affects the contractors’ relative position).

In the context of bounded rationality, instead, information can be supposed to be freely available in the external environment, the market being a subset of it (Simon, 1956). The constraint to the acquisition of knowledge is determined by the limitation in the agents’ capabilities to process (Simon, 1956, 1978, 1986) and communicate (Polanyi, 1962; 1966; Hayek, 1978) information. Cognitive limits affect both interpretation (representation) and communication (symbology) (Le Moigne, 1973). Acquisition of information does not correspond to the production of knowledge. In this context, which is characterised by dispersed knowledge (Antonelli, 2005) – heterogeneity of agents – and by inefficiencies in the management of its flow (Breschi and Lissoni, 2001) – presence of tacit knowledge –, firm and relational structure can reduce the impact of those two elements. The interactive learning reduces the problem linked to dispersion, while the capabilities in term of communication of the organizational structure mitigate the effect of the tacit component of the knowledge by means of maieutics and elicitation processes (Nonaka, 1994; Nonaka e Takeuchi, 1995). Knowledge comes from the processing of information, from the capabilities to contextualize information (acquisition and interpretation) and to make it available to others within the structure (communication).

The differentiation between knowledge and information can be interpreted also based on the nature of their role within the process of development of firm’s capabilities. Generally, knowledge is a resource, a stock of competencies that can have different degrees of genericness/specificity according to the nature of the savoir-faire. Information is instead an asset, an input whose degree of utilisation and efficiency has to be determined in a systemic fashion. Those magnitudes have a cumulative causation relation: the presence of a generic resource (early stock of knowledge) allows the specification of a generic asset (acquired information) through its processing, thus permitting a process of further specification of the resource itself (evolution of the stock of knowledge). In this context, learning processes would not derive only from the acquisition of information, but it should be affected also by the stock of initial
knowledge. Then, knowledge is not just an outcome but it is instead also an input of the learning process (Antonelli, 2005).

This cycle knowledge-information-knowledge represents the core of the analysis of the development of firms’ resources. It allows the determination of the evolution of firm’s capabilities from a path dependency perspective (the result of the process is the input for the replication of the cycle on a cumulative basis), and from a creative destruction perspective (when the process of specification of the knowledge stops and the acquired knowledge is anew generic and it has to be re-specified within the new context). A scheme of the proposed reasoning is depicted in figure 4.

![Knowledge-Information-Knowledge Cycle](image)

The knowledge-information-knowledge cycle is activated by the learning process, which has two specific functions in this case. On one hand, being a «process phenomenon», it tends to determine the evolution of behaviours, through the selection of efficient ones and the exclusion of those inefficient (stabilization of the owned knowledge) (Nelson e Winter, 1982; Cyert e March, 1963). On the other, it can lead to the emergence of new behaviours, not directly selected from a previous set, but that are in some way discovered throughout the processing of novel information (new knowledge generation).

Indeed, March (1993) defines two different typologies of learning. Exploitation refers to the capabilities to improve the efficiency in solving a given set of actions, that is, a procedure. Exploration refers instead to the capability to solve novel problems. The two typologies of learning refer to different contexts and capabilities. By definition, exploitation learning is an unvaried information process: new information is omitted and the processing is a re-interpretation of the owned information. Instead, exploration learning is a process based on the processing of novel information.

Exploitation allows the sharpening of the acquired knowledge, while exploration allows the widening of the knowledge basis. In terms of the knowledge-information-knowledge cycle, exploitation learning produces a progressive specification of the early amount of knowledge, while exploration enables creative destruction processes, whereas the previous knowledge is utilised as a cognitive ground. The capabilities to enable the different typologies of learning are determined by the capability to acquire the
information on one hand, and to interpret and communicate it on the other. Both capabilities are affected by the stock and the characterisation of knowledge – individuals’ «absorptive capacity» in the terminology of Cohen and Levinthal (1990) –, and by the level in which they are enabled by the organizational coordination – which represents the firm’s «absorptive capacity». Indeed, acquisition of information is an individual process, which depends on the capabilities that agents are enabled to utilise according to the level of discretion permitted by routines. Instead, interpretation and communication are collective process, whose intensity is affected by the rigidity/flexibility of the relationships between agents determined by the coordination design (allowed degree of heterogeneity, value of $R$).

Generally, more flexible routines design will allow a higher utilisation of the potential cognitive distance, enabling the acquisition and the processing of bigger amounts of information. The design of routines, in fact, affects the subjective dimension (acquisition) as well as the collective one (interpretation and communication). A larger space of possibilities will involve that single agent will acquire a bigger amount of informative signals, while the increasing intensity of the interaction (increase in heterogeneity) will involve higher interpretation capabilities.

As we have stressed in the definition of cognitive distance, a constraint exists to the efficiency with which increasing levels of cognitive distance can process information and, consequently, create knowledge. The efficiency of communication of informative signals is negatively affected by noise and dispersion of the information that are produced within the code of communication, thus influencing the interpretative process. This means that, even if there is an increasing relation between flexibility of routines and capability to create knowledge, such process has decreasing returns as long as the volume of processed information rises.

There are two constraints to the generation of increasing volumes of knowledge, which work respectively on the acquisition (utilised cognitive distance) and on interpretation and communication (efficiency of the utilised cognitive distance) of information. They involve the permanence of a certain degree of radical uncertainty. Indeed, although increasing the capabilities to acquire and process information is possible, it is conversely impossible to achieve the level of knowledge that defines certainty.

In the case of acquisition, the cognitive distance necessary to acquire all available signals is equal to its unitary value, that is, the agents’ total heterogeneity. This value is unachievable for any organization because there would not be a sharing space of coordination. This means that the maximum value of the function that describes the trend of the necessary cognitive distance is superior to the maximum value achievable by the potential cognitive distance (incommunicability constraint). The trend of the function that links the necessary cognitive distance to the level of information to be acquired is supposed to be convex, because the acquisition of relevant signals becomes more difficult as long as the stock of owned information widens. For high level of information, therefore, the acquisition of relevant signals calls for capabilities, which increase in a non-linear way. In other terms, while the relation that links utilised cognitive distance to the flexibility of routines is linear, that which links the necessary cognitive distance to the acquisition of a given amount of information is convex.

In the case of processing, a constraint prevents the processing of a level of information coherent with the definition of the certainty. Such constraint is produced by two causes: on one hand, by the fact that the maximum potential cognitive distance of
an organization does not allow the acquisition of all relevant signals (as we have seen above); on the other, the need in terms of communication of high level of information are not supportable by the firm’s codes of communication. In other terms, while the efficiency of the utilised cognitive distance has a concave increasing trend with respect to the increase in heterogeneity, the necessary efficiency of the cognitive distance has a convex increasing trend with respect to the rise in the volume of information to be processed. Particularly, the curve that defines the need for processing efficiency will have a more convex trend with respect to that which characterised the need in terms of acquisition of information. This happens because the communication needed within the processing of information makes more complex the process of generation of knowledge with respect to that of the simple acquisition of informative signals.

The effect of the code of communication – implicit in both the concavity of the efficiency of the utilised cognitive distance and in the convexity of the necessary efficiency of the cognitive distance – depends on the fact that for information to be transmitted without any ambiguity, a code of communication needs which contains a number of strings higher than that of the signal it has to spread. In the case of the efficiency of the utilised cognitive distance, once given the fixed amplitude of the firm’s code of communication, the increase in the information to be carried creates ambiguities that compromise efficiency and makes the function concave. In the case of the necessary efficiency of the cognitive distance, this involves that the function will have a steeper convex trend with respect to the cognitive distance necessary for the simple acquisition of information, because it involves its proportional increase for any given level of information.

5. The emergence of heterogeneity and the decision on specialization

5.1 The model

The relevant magnitudes for the determination of the information $I_a$ the firm is able to acquire are: the potential cognitive distance $\alpha$ expressed by the structure; the utilised cognitive distance $D_c$ as a function of the degree $R$ of flexibility of routines; the necessary cognitive distance $D_n$ for each level $I$ of information. Taking into account the Shannon and Weaver’s (1949) definition of information, we will have that $0 \leq I \leq 1$.

The degree $R$ of flexibility of routines varies between zero (maximum rigidity) and the unity (maximum flexibility), while the potential cognitive distance will vary in the space $0 < \alpha < 1$.

In functional terms, once given the above definitions, we will have

$D_c = Ra$, with $0 \leq R \leq 1$;

$D_n = f(I)$, with $0 \leq I \leq 1$, whose trend is determined by $f'(I) \geq 0$ ed $f''(I) \geq 0$, and depicted in figure 5.

Once given any value of $\alpha < 1$, and chosen any value of $R$, the amount of the information acquired by firm will be such that $D_c = D_n$, or better, $\alpha R = f(I)$.

The trend of the $f(I)$ represents the boundary of the possibilities of the firm in acquiring information. Indeed, amounts of information for which $f(I) > Ra$ are not achievable.
The relevant magnitudes for the determination of the information $Ie$ the firm can process are: the efficiency of the utilised cognitive distance $EDc$ as a function of $R$; the level of necessary efficiency of the cognitive distance $EDn$ for each level $I$ of information to be processed; the code of communication, determined as a function of $\alpha$, which affects the trend of the $EDc$.

In functional terms, we will have that:

$$EDc = f(R),$$

with $0 \leq R \leq 1$, whose trend is defined by $f'(R) \geq 0$ and $f''(R) \leq 0$, with a $\max = \alpha$ for $R = 1$; 

$$EDn = (1+\varepsilon)f(I),$$

where $(1+\varepsilon)$ represents the necessity in terms of code of communication.

Once given any value of $\alpha < 1$, which also determines the internal code of communication, and once chosen any value of $R$, the amount of information the firm can process will be such that $EDc = EDn$, or better, $f(R) = (1+\varepsilon)f(I)$ (figure 6).

Also in the case of processing, the condition $(1+\varepsilon)f(I) > f(R)$ borders the space of the informative amount the firm is able to process.

5.2 Implications of strategic choice

The first consideration regards the fact that, once the choice is made, the decision on the level of flexibility of coordination represents a constraint to the expression of the acquisition and processing capabilities. Taking into account that as long as $R$ increases firm improves its capabilities to both acquire and process information, this model is able to stress the lock-in effect that routines have on the development of new knowledge.
The second consideration regards the relative trend of the increase in the capabilities to acquire and process information as long as $R$ rises. Starting from a low value of $R$, and making increase its value to the threshold of firm’s acquisition and processing possibilities (determined by the conditions $f(I) \leq Ra$ and $(1+ \varepsilon)f(I) \leq f(R))$, we find that as long as $R$ increases the firm steps from a situation in which its capabilities to process information are higher than those of acquisition, to a symmetric situation, in which it is not longer able to process all the acquired information.

This relative trend of the capabilities to acquire and process information depends on the effect of the code of communication, which does not affect the acquisition, but instead imposes a concave trend to the growing of the processing efficiency. This means that processing of information initially shows increasing returns and then steps to decreasing ones. As long as the processing needs increase, the inefficiencies, which are imposed by the defects of communication, impinge in increasing way, thus preventing the efficient flow of information.

This evidence is interesting because it characterises the strategy that is beyond the choice on the value of $R$. Rigid designs impose a strategy aimed at relatively minimizing the acquisition of information, concentrating the processing capabilities on a small number of signals. This enables exploitation processes. Indeed, those processes are aimed at acquiring small amounts of information, while the processing capabilities are utilised to enable improvement processes on behaviours, which derive from the acquired information. In this case, the higher degree of homogeneity, which is imposed to the structure, allows a clear interpretation and communication of the acquired information, contributing to the definition of a more stable operational environment.

Conversely, designs that are more flexible allow a higher access to information and relatively maximize the amount of acquired information, leaving aside the fact that this involves some dissipation of signals. This choice on the typology of coordination enables the exploration processes. They are characterised by a higher amount of acquired signals, which are processed with the goal to produce novel solutions. In those processes, the collecting of information must allow a quick turnover of the owned information, whereas this possibility comes from the higher degree of heterogeneity within the structure of relationships. The processing is in this case less efficient. However, it allows the firm to achieve higher level of knowledge. Thus, the decision on the coordination design can be interpreted as a choice that affects the learning typology the firm will tend to utilise in the process of generation of knowledge, within the knowledge-information-knowledge cycle.

5.3 The strategic choice

Firm’s goal, in this context, will be that of achieving the highest efficiency of the learning processes that are enabled by the form of coordination. The strategic lever is represented by the possibility to manage the design of routines, that is, to work on the value of $R$. Efficiency of the learning processes can be defined by means of the comparison between the utilised amount of information and the degree of knowledge obtained by means of it, that is, in the context of our model, by the difference between acquired and processed information.

Being under hypothesis of bounded rationality, the decisional processes, which lead to such choice, are not determined by the optimization of the degree of flexibility of routines in terms of some magnitude. For a descriptive purpose, however, we can suppose that firm will tend to choose the level of $R$ that will guarantee the highest
efficiency of the cognitive distance with respect to the degree of utilisation of the potential. If we have to suppose that decision makers are not able to correctly derive the values of functions, however we can suppose that firm will decide on the value of $R$ taking into account the difference between $EDc$ and $Dc$.

Formally, we will have that

$$R = \arg \max (EDc - Dc),$$

thus the condition will be $\partial EDc/\partial R = \alpha$.

From that condition, we can draw two considerations. The first is that the choice on routines design is dependent on the characteristics of the structure. The second is that this relation imposes a positive rapport between the value of $R$ and the potential cognitive distance the structure expresses. The first result allows us to establish a correspondence between the agents’ characteristics and the typology of the coordination that is efficient. This relation represents the interference effect that agents’ characteristics have on the form of coordination. The second result stresses the typology of the relation that links agents’ characteristics to the typology of coordination. The higher the potential of cognitive distance is, the more firm will have the convenience to exploit it by means of a less rigid design of routines.

5.4 The heterogeneity

Thus far we have analysed single firm’s knowledge generation process, deriving the reciprocal influence of strategic and structural dimension of heterogeneity. Stepping to the comparison between two firms (whose graphical representation is depicted in figure 7), some implication emerges, which deserves to be commented.

![Figure 7](image)

Once given two different levels of $\alpha$, we can characterise two firms whose structure expresses different potentials of cognitive distance (structural dimension of heterogeneity). Supposing the optimum strategic decision (strategic dimension), which determines the value of $R$ on the basis of the above stressed condition, we will have that firm with higher cognitive potential will tends to most exploit the potential contained within its structure. In the proposed example, it emerges that the two firms, even if they obey to the same decisional procedure, will make different strategic decisions. Firm 1 will tend to enable exploitation learning, while firm 2 will tend towards the enabling of exploration learning.
The different layout of the knowledge generation processes enabled by the structure leads to a different propensity towards the static or rather dynamic efficiency. Indeed, the firm with less cognitive potential will result more willing towards static efficiency, that is, towards the maintenance of an operative efficiency linked to stable environment, which also involves lesser attention devoted to resources development (Nooteboom, 1999). This implies, from an evolutionary perspective, more pronounced fragility facing the variation in the operational context, because the bigger incidence of the lock-in effect of routines would prevent the firm to be quickly adaptive.

Conversely, the firm with higher cognitive potential will be more efficient from a dynamical point of view. Its coordination will be oriented towards resources development. This implies, from an evolutionary perspective, higher adaptability, because the higher degree of flexibility of routines guarantees a lesser incidence of the lock-in effect.

Thus, the structural characteristics, affecting the strategic choice, determine the typology of learning that the firm utilises to acquire and process information, and, consequently, the relative efficiency of the two firms according to the temporal horizon in which they are placed. Such difference in the typology of efficiency cannot be judged, because a priori nothing imposes to considerate one typology better than other. Simply, they represent the expression of the heterogeneity induced by the two proposed dimensions. On the other hand, as it is easy to deduce from figure 7, neither of two firms can be considered more efficient than the other along the whole horizon determined by increasing amounts of information. Firm 1 is more efficient for low level of acquisition and processing of information (in stable environment, static efficiency), while for high level of acquisition and processing (in instable environment, dynamic efficiency), firm 2 will be more efficient.

This conclusion, which stresses the typology of the relation that links the features and the direction of the resources development based on the form of coordination chosen by the firm, completes the frame of the mutual interference between the development of cognitive capabilities and the form of design that determines their level of utilisation.

Furthermore, the inversion in the firms’ relative efficiency has also the role of binding eventual wrong strategic choices. Indeed, under the hypothesis of bounded rationality, we cannot exclude that firm is not able to correctly determine the level of R coherent with its structural characteristics. In this case, the constraint imposed by the reversal of relative efficiency can work as an indirect signal for the decision-maker, informing him/her that the choice is wrong: in the proposed example, firm1 (firm 2) cannot maintain a level of R higher (lower) than that which marks the reversal of relative efficiency. In this case, in fact, the firm would impose to its structure learning processes that the other carries out with higher efficiency. Then, finding out lesser efficiency with respect to the other firm, can work as an indirect signal of a wrong strategy.

Concluding remarks
The process of de-integration and the tendency towards technological and functional specialization have developed themselves simultaneously with the progressive increasing openness and internationalization of goods and capital markets, and the emergence of technologies characterised by an increasing degree of complexity (Feenstra, 1998). The openness and internationalization of markets have produced a
reduction in transactions costs. On the other hand, the costs connected with the big hierarchical structure have tended to increase in the countries characterised by mature industrialization. Thus, de-integration can be seen as a process prompted by the change in the relative rapport between production and transaction costs.

The process of specialization and the emersion of an increasing tendency towards firms’ heterogeneity in both structural and strategic dimension cannot be explained within the same framework. The idea that those phenomena have to be defined starting from the technological context is also present in the works of Williamson (1975, 1985, 2001). That notwithstanding, as pointed out by Conner (1991), the approach of transaction cost economy remains too much linked to a «technological determinism» that is not characterised in a satisfactory way. On the other hand, neither property rights nor incentive design deal with the issue linked to the evolution of technology and to its influence on organizational forms and firms’ heterogeneity.

In order to characterise the influence that technology and operational context have on both strategic decision and firms’ structure we need to take into account the processes through which firms manage and produce knowledge, that is, the elements that characterise the management and the development of agents’ cognitive resources. The utilization of a given technology, or the carrying out of a certain function call for capabilities, which are generally different according to the carried functions and the implemented technologies. Such capabilities can be defined in terms of different level of knowledge and different typologies of learning processes necessary to develop the level and the typology of the requested competencies. On the other hand, once the firm is defined as a structure of interaction between agents, it has to show the capability to develop an organizational design aimed at permitting not only the flow of the information which is needed to that we defined the passive dimension of governance, but also that which is needed to enable learning processes (active dimension). Under the hypotheses of bounded rationality and instable environment, and once given the characteristics of non-exhaustivity and dispersion of knowledge, forms of interactive learning enabled within the firm allows higher efficiency in managing and exchanging knowledge, and in producing new representations. Thus, in this context, firm does not met its nature in the mere comparison between transaction and production costs relative to the exchange of goods and to the management of investment, but also in the comparison between transaction and production costs concerning the exchange of knowledge.

On the other hand, firm’s efficiency in managing and exchanging knowledge meets its limits in the possibility to efficiently manage increasing amounts of information, particularly when it refers to different cognitive ambits. The heterogeneity that the structure has to support becomes progressively unmanageable and, consequently, the firm erodes away the scale economies of cognitive scope permitted by interactive learning. Generally, the point in which the scale economies start to reduce themselves will depend on the agents’ characteristics. Thus, strategic decision has to take into account the firm’s structural characteristics. These latter, on the other hand, retroact on agents’ interactive capabilities, allowing the enabling of qualitatively different learning processes according to the degree of heterogeneity that is permitted by coordination design. Then, it emerges that firms have to manage a trade-off between advantages and
disadvantages of heterogeneity, having to take into account the potentiality inbuilt within their structures.

Furthermore, firm’s strategic choice will be bound by the comparison with the capabilities that other firms have in carrying out the management and the production of knowledge. The fact that some firm results more efficient that others (and vice versa) according to the level of knowledge they are coping with, and to the typologies of learning processes enabled within, allows us to link the heterogeneity to the choice of specialization. Indeed, in the proposed example, the two firms, which were structurally heterogeneous, despite they were following the same rules with respect to the decision on coordination design, tended towards specialization on typologies of learning that guaranteed them the best relative efficiency with respect to the other one.

Thus, the process of specialization would derive from the firms’ need to manage the learning processes so as to maintain higher efficiency with respect to market (and other firms) in coordinating the exchange and the production of knowledge. We have seen that this involves a narrow relation, which links the firms’ structural characteristics to both strategic choice and learning processes. Such a difference in the learning processes allows the characterisation of the typology of the specialization that firms will undertake from both functional and technological point of view.

From the point of view of the function carried out along the value chain, firms that concentrate on productive phases have to develop mechanisms of managing and producing knowledge different from those necessary for firms that specialize in strategy and marketing. Exploitation learning characterises the productive functions. Here, the higher stability of the operational context makes mechanisms that tend to eliminate problems more necessary. Exploration learning, on the other hand, will characterise strategic and marketing functions. Here, operational contexts are more instable and the capability to manage large amounts of information, heterogeneous signals, and to produce new knowledge, becomes essential.

From the technological point of view, firms that operate in stable or rather instable technological contexts will have different needs in terms of learning processes. The more mature, and manageable within a stand-alone development context, technologies are, the more exploitation learning will tend to be privileged. On the other hand, as long as the complexity and the instability of the technologies increase, exploration learning will be privileged. Particularly, this last is the case of systemic technologies.

When learning processes tend to differentiate themselves through the strategic choice, such phenomenon affects the typology of coordination. Exploration learning, needing higher impact of the elements of heterogeneity and higher intensity of interactions between agents, will tend to define more flexible (and decentralised) coordination design. The symmetrical situation will characterise the case of exploitation learning.

Finally, from a theoretical point of view, a consideration has to be deserved to the fact that the proposed scheme is not in contradiction with many of the results of transaction costs economy. Quite the opposite, the cognitive approach can allow the
widening of that framework. Indeed, the approach presented in this work can represent an interesting bridge between transaction cost economy and those are defined adaptation theories. The analysis of an active dimension of governance complements but does not invalidate the formulation proposed by Williamson. It opens the horizon of analysis to the study of not only the consequences of the inefficiencies of market form the point of view of the transaction concerning goods and investments, but also from that, progressively more important nowadays, of the transaction that have knowledge as the object.

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