Unveiling the Systemic Nature of the Firm using a Grammar of Social Processes

Bruno Braga
brunodarochabraga@gmail.com
Central Bank of Brazil and Federal Institute of Education, Science and Technology of Brasília

Abstract. This paper proposes a meta-theoretical framework to explain all forms of economic coordination with a computational complexity approach, taking into consideration the contractual (or transaction costs-based), the competence-based and the relational views of the firm. A mathematical model of the sequences of decision-making events of either individual action or social interaction like that from Generative Grammar Theory makes a clear distinction between the market and all other coordination structures, including the firm. Finally, the contribution mechanism of this kind of systemic view of the firm as an extension of the social processes of competence development and inter-organizational relationship is presented.

Keywords: Critical Realism; Social Ontology; Theory of the Firm.
JEL Classification: D21, C63, L25

1 Introduction

There is an existential dilemma at the core of economics and management research: “Why do firms exist?” or in other terms “Why cannot the market do everything?” This question bears a resemblance to an equally famous but far less controversial conjecture: “The market economy always outperforms the central planning economy.” Considering the firm is a kind of central planning bureau for the production of goods and services, the following paradox arises: if central planning does not outperform the market and if the firm cannot do it too, then why does the firm still exist? Even more surprising, how can firms multiply and grow in the long term?

The first person to successfully challenge this paradox was the 1991 Nobel Prize in Economics, Ronald Coase – in the seminal paper “The Nature of the Firm” (1937), five years after a lecture at Dundee University in which he presented the idea for the first time. Despite the fact that the academic community largely ignored this paper for half a century, it is by now the most widely acknowledged theory of the firm.

Coase observed that using the market to buy goods and services always implicates transaction costs, which may happen before the action of exchange

itself (e.g., seeking the best offer, formulating a contract), or even after that (e.g., evaluating the outcome, enforcing the contract). He proposed the mechanism of why firms bloom and grow: every time the costs of exchanging a good or service in the market (i.e., the transaction costs) are greater than the costs of coordinating the production of it within the firm's bureaucracy (i.e., the administrative costs), the internalization of this activity into the firm maximizes the creation of value. Finally, if conditions for the managerial practice such as institutions and technology evolve, then the administrative costs may become greater than the transaction costs instead. In circumstances of changing costs, the choice that maximizes value creation is the externalization of economic activities with lower transaction costs to the market. Therefore, a never-ending sequence of "make-or-buy" decisions determines the evolutionary path of the firm. The process of competition adjusts the configuration of the governance of economic activities between market and hierarchy. This is due to the tendency of pushing the firms that become inefficient in terms of costs not related to the production of goods and services out of the market.

In spite of being opposed to the neoclassical view of the firm as a production function that transforms inputs into outputs using technology, Transaction Costs Theory turned out to be the mainstream paradigm for the economics of organization: the contractual (or contract-based) view of the firm (Alchian & Demsetz, 1972; Williamson, 1975). Since then, all competing views have taken a critical stance against the main proposition of the contractual view – the firm as a "nexus of contracts" – rather than that of the neoclassical view – the firm as a "production function."

The main rival is the Resource-based view of the firm (Penrose, 1959; Wernerfelt, 1984). It argues for the neglect of the productive activities in the contractual view and suggests to replace transactions for resources as the unit of analysis when studying the phenomenon of the growth of the firm – the firm as a "bundle of resources." Moreover, this view admits the possibility of competitive advantage relying upon non-tradable, idiosyncratic resources, which have strategic meaning only to the firm in which they are deployed (Barney, 1991; Peteraf, 1993). Therefore, there is more than one resource-based view of the firm, each stressing one type of strategic resource, such as productive knowledge or interorganizational relationships with other firms and industry supporting institutions. On the one hand, the Competence-based view of the firm (Prahalad & Hamel, 1990; Teece, Pisano, & Shuen, 1997) emphasizes productive knowledge, in the form of routines: it takes the relation of production instead of the relation of exchange as the constitutive element of the firm. On the other hand, the relational view of the firm (Dyer & Singh,

1998; Lavie, 2006) emphasizes the extra-contractual, production-oriented characteristics of long-term exchange relationships of the firm with other organizations. Both branches highlight the cognitive and social features of other forms of governance structures, which enable the exploration and the exploitation of strategic productive resources (e.g., learning and innovation for knowledge resources, repeated transactions and trust for relational resources).

As discussed below, some assumptions of the contract-based and of the resource-based views of the firm appear to be irreconcilable. In addition, both fail to answer one or more of the key questions about a theory of the firm: (1) *existence* ("Why do firms exist?"); (2) *boundaries* ("Which economic activities are internalized in the firm, and which are transacted in the market?"); and (3) *performance* ("What are the determinants of an efficient economic coordination?"). Nonetheless, taken together, these theoretical views appear to provide answers to concrete firms in real empirical settings, respecting the complexities and specificities of economic organization. In this sense, the objective of this paper is to provide a meta-theoretical framework to compare the market with all other non-market forms of governance structure using a computational complexity approach, which conciliates the main competing theoretical views of the firm.

1.1 Dilemmas Blocking the Consensus around a General Theory of the Firm

Since the seminal work of Ronald Coase about the "nature of the firm" (1937), the question of "what is the firm?" remains open despite the increasing debate between advocates of the contract-based view and of the resource-based view. For Coase, the firm manages a bundle of transactions of goods and services with other firms by means of contracts; it is a "command-and-control" adjustment system of the production under hierarchical coordination, in contrast to the "supply-and-demand" adjustment system of the production under decentralized coordination.

Some transaction costs theorists, such as Alchian and Demsetz (1972), consider that markets and bureaucracies are functionally equivalent structures for the coordination of economic activities: the mechanism of choice is just the one that minimizes the costs not related to production itself. These people pay no attention to the non-transactional and non-instrumental features of the firm. However, there are other authors like Oliver Williamson (1975) stating there are still qualitative differences between the two "pure" forms of economic organization. The major assumption of the resource-based view is also that there is a neglect of the limits of contracts as well as of the non-contractual

dimensions of transactions (i.e., social and cognitive features such as moral norms and knowledge).

In this sense, the contract is not merely a matter of intentions since there are social and regulatory issues enforced by surrounding social structures constraining economic activities (e.g., institutions on the endogenous change of preferences, long-term interorganizational relationships on trust, loyalty and reputation). These structures influence the decisions of the firm in a non-economic and non-trivial way.

Therefore, the linear, static and universalistic modeling of coordination structures based on the minimization of transaction costs ignores several complex, dynamic and contingent features of economic organization, such as learning, innovation, cooperation and sustainability. The focus is not on the explanation of production structures, capital accumulation and growth, but on the choice of governance structures, contracts and allocative efficiency. The contractual view reduces the problem of organizing to single, independent choices for the optimization of exchanges; overlooking social processes involved in production (e.g., organizational learning and change) that affect both agents and social structures. These dilemmas prevent to conciliate the contract-based view with the resource-based view in favor of a unified theory of the firm.

The problem is not only about the nature of the firm, or precisely what it is. Whatever your approach to produce knowledge on a specific object of studying, it should always rely on the assumptions about its nature. There is definitely an inadequacy in the way people do social research as another reason why there is no consensus on a unifying approach to studying the firm.

1.2 Ontology, Epistemology and Methodology to Explain the Firm

There are ontological and epistemological divergences between the contract-based and the competence-based views of the firm (Foss, 1996; Hodgson, 1998). On the one hand, the contractual view is not far from the assumption of static equilibrium from neoclassical economics: it is the studying of a specific point of equilibrium. On the other hand, the competence-based view relies on the assumption of non-equilibrium of the evolutionary economic theory (Nelson & Winter, 1982): it is the studying of the processes that transform the economy from within. However, these researchers are far from the consensus about which view is the most relevant to studying the firm because the most promising trend in theorization appears to be the proliferation of many middle-range explanations for real-life firms rather than a general theory of the ideal firm. This approach requires deep methodological changes to become fruitful yet. It needs to be capable of formulating and comparing middle-range

theories, even though some of the necessary tools have not yet come into being.

The epistemological stance of Social Positivism, which supports the neoclassical and contractual views, considers causality as general laws (Lawson, 1997). The validity of a law is independent of the empirical domain under inquiry; it is possible to predict outcomes based on the observation of the hypothesized causal factors only. In line with the naïve-realist metaphysics in which Positivism relies on, theories become accurate representations of reality. However, this philosophical approach often cannot explain the emergence of social phenomena.

Consider that social forms are epiphenomena of the evolution of underlying social processes. Any repeating pattern of sequences of decision-making events about either individual action or social interaction carried out by social actors is a category of social process. Decisions are strategic or operational, either economic or non-economic, by internalizing or externalizing the production of goods and services. What do they have in common? They are made by the people affiliated with the bureaucratic body of the firm: social actors (not economic agents) interacting between themselves as well as with other organizations surrounding the firm, but in stable, well-defined patterns of events. These people lead the firm through many evolutionary trajectories of decision-making events in response to each of the existing environmental challenges and those yet come into being, which may also transform these patterns over time. Each event outcome results from the activation of a non-observable mechanism supported by the operating social structures in an empirical setting under inquiry.

This understanding bears a resemblance to a different epistemological view: Critical Realism (Archer, 1995; Bhaskar, 1975). Here, theories are simplifications of reality that are always incomplete because the social structures change over space and time, which implies a high level of uncertainty about all structural relations operating in a concrete social system. These activated mechanisms generate sequences of formative relations between the decision-making events. The power or capacity for action of the enrolled agents activates a social mechanism that is sensitive to the context in which it occurs. The search for structures that are contingent upon the underlying contextual conditions using empirical data aims at the refinement of the theoretical constructs and relations between them. This alternative research approach aims to explain specificities rather than to predict generalities about the phenomenon under inquiry.

The present paper suggests modeling both the firm and the existing theories of the firm themselves based on the ontological and epistemological as-

sumptions of Critical Realism; however, against the belief on formal theorizing losing ground (Castellacci, 2006), it offers a mathematical model of social processes (Braga, 2020) deduced from the Generative Grammar Theory (Chomsky, 1956, 1959) with respect to the formalism of Category Theory (Eilenberg & MacLane, 1945; MacLane, 1948). It is an analytical framework for studying a category of social process as the result of an automaton that also equalizes the conceptual and empirical knowledge about a complex, dynamic and contingent social phenomenon. Thus, the social researcher still interprets the evidence of theoretical relations within empirical instances of decision-making events regarding the historical context of a real economic agent embedded in a concrete socioeconomic system.

2 The Case for Another Theory of the Firm

The deliberate nature rather than the emergent nature of social order distinguishes the firm and the market, respectively (Hayek, 1998). On the one hand, the market is a social system comprising horizontally structured relations of exchange between loosely coupled economic units only. On the other hand, the firm is a social system comprising also vertically structured relations of production between tightly coupled organizational units. The rise of organizational complexity in the firm occurs through the development of some social mechanism that the “supply-and-demand” adjustment system based on market prices could never support; after all, the lowest level of coupling between the economic agents in market transactions is the structural requirement preventing it.

The process of coordination is the alignment of decisions to manage dependencies between productive units either in the firm or in the market. A pair of economically interdependent activities exists if the decision outcome in the focal activity depends on another outcome of a decision made previously. The administratively coupled decisions take place if and only if people in charge of them have got in touch and hold a kind of memory about what is going on in the future. The interdependence between activities occurs both in the firm and in the market; nevertheless, the deliberate increase in the level of coupling between interdependent activities occurs in the firm and other non-market forms of economic organization only. The firms are hierarchical organizations comprising nested, interdependent productive activities with a high level of coupling between them (Siggelkow & Rivkin, 2008). In contrast, the lowest level of coupling between firms takes place in the transactions of a free-market only, which is a kind of “memoryless” structure.

This paper proposes the firm is neither a “nexus of contracts” (Coase, 1937) nor a “repository of resources” (Penrose, 1959); instead, the firm is a kind of “complexity-enhancing mechanism” that enables and justifies its existence over time by satisfying needs of the socioeconomic system in which it is embedded. On the one hand, all needs come from the market and other social structures in the environmental surroundings of the firm improving the market functioning. On the other hand, the firm counts on non-financial, idiosyncratic resources provided by the network partners in its organizational surroundings to satisfy these needs – after all, money is a raw resource, but the *source* of money may be an idiosyncratic resource. The idiosyncrasy of shared resources and the systemic nature of needs defined by environmental social structures other than the market, which can only be satisfied by the firms with the support of other institutions in their organizational surroundings, determine the types of relations that the firm holds with its socioeconomic system.

Here, the goal of the firm is not “profit maximization” nor “sustainable growth,” but merely “structural fit” by the satisfaction of needs – as in Herbert Simon’s Satisficing Theory (1956) – from both the market and other social structures. The firm may reach this goal by solving competitive problems within its socioeconomic system that are undermining its performance. Moreover, the firm plans ahead a sequence of events of either individual action or social interaction targeting a problem, but each conceivable event outcome deterministically results from a configuration of past event outcomes in a way that is contingent.

The firm is a kind of “device” for the activation of social mechanisms that generate sequences of decision-making events for resource allocation in the search for systemic competitiveness (Esser, Hillebrand, Messner, & Meyer-Stamer, 1995). There are many concurrent patterns of sequences of these events defining the existence, boundaries and performance of the firm in a chaotic, evolutionary way. In this sense, there may still be a *systemic problem* (Chaminade, Intarakumnerd, & Sapprasert, 2012) lying on the road to the solution of a competitive problem, that is, a problem that affects everybody within the socioeconomic system, but which no one has all the required resources to solve it.

In the present section, the role of the firm is redefined in terms of competence and performance much like what is required for mastering a language, but in this case, the language of the systemic relations necessary to the existence of the firm. Each structural dimension in which the firm is embedded is a dynamic system like language itself. The firm resembles an automaton capable of acknowledging sequences of decision-making events for satisfying sys-

temic needs in the same way the language speaker resembles an automaton capable of acknowledging valid sentences by means of mastering the use of grammar rules. However, the firm is never alone in its mission. The question of what is the nature of the firm gets a new answer in which it is a computational unit embedded in a pattern recognition system for the improvement of economic governance, but the market is only one layer of the required infrastructure; more precisely, the one at the bottom of the hierarchy of complexity levels.

Considering the firm is an economic agent embedded in a socioeconomic system of production, this meta-theoretical framework can reconcile distinct theoretical views to analyze the way that firms really make decisions, but it also admits the systemic nature of the relations of the firm with the surrounding social structures, which is neglected in the main theoretical views.

The next section presents the concepts of path-dependence and contingence in order to apply both the process tracing and the systematic case comparisons methods to the analysis of causal complexity, which is consistent with the critical realist assumptions.

2.1 Path-dependence and Contingence

Social forms and social outcomes do not result as a net-effect from a conjunction of causal factors; instead, they may emerge from a social system comprising a complex of social structures generating many concurrent chains of coupled decision-making events that exhibit the property of *path-dependence* (Bennett & Elman, 2006).

Each event outcome relies on formerly generated event outcomes as well as on other conditions external to the social system that together turn out to be the context of the phenomenon. The behavior of the social system may change over time following a new context, which is a specific configuration of past event outcomes under influence (or not) of new external conditions that determines the occurrence of a new pattern of event outcomes. This new configuration of contextual conditions activates a latent generative mechanism, which relies on existing (or new if the system is open) structural relations between types of events, exhibiting the property of *contingence* as well (McConwell, 2019).

In any state transition of the system, a new configuration of contextual conditions may generate a surprising event outcome that determines the future development of the social process under inquiry. In this situation of a new context that becomes persistent, the resulting new pattern of event outcomes may become recurring. If a surprising event outcome repeatedly occurs in one

or many instances of a concrete category of social process, then a new generative mechanism has been activated because of that specific context, which differentiates a new category (i.e., an extension of the original category). The modification of the operating relations in the existing social structure also produces a new social system (i.e., an extension of the original system). Thus, the social system as a whole has evolved in these empirical settings. The concept of path-dependence applies not only to the sequences of events but to the social structures generating them too; both them exhibit an evolutionary trajectory across history marked by change on the observed patterns.

If the behavior of the social system evolves over time following the unpredictable influence of an endogenous (or exogenous) change over the configuration of past event outcomes (or over the existing complex of social structures) in that empirical setting – it is a closed (or an open) system –, then the concrete category of social process under inquiry exhibits a new historical development. If the social system is an open system then a new social structure comes to be part of this concrete category at some moment in time. However, in both situations – the incorporation of a new mechanism because it is an open system, or the activation of an existing latent mechanism for the first time ever –, this change can be represented in the model of this category of social process using the same mathematical formalism, which is going to be shown in this paper yet.

The firm, as it blooms and grows, becomes an evolving social system because of its properties of path-dependence and contingence, which are both empirically observable. In this systemic view of the firm, there is the need for a unifying social ontology of the phenomenon of economic organization as well as for a discrete mathematical model to describe the complex, dynamic and contingent features of social processes occurring in the firm. The next section recommends the model of generative linguistics, which is already in use in computer science, genetics, and many other fields of science as well, to grasp the dynamic system of relations between the firm and its surrounding social structures as a kind of formal language.

2.2 Competence and Performance

Generative linguistics is an analytical approach to the studying of natural language; it proposes modeling the linguistic knowledge in a formal way relying on the grammar rules to use the respective language. Precisely, this paradigm of linguistics is a rational framework of human cognition based on two concepts (Chomsky, 1965): *competence* and *performance*. The first concept represents the system of linguistic knowledge that every native speaker of a natural language own: the set of grammar rules of the formal practice of a

natural language represents its linguistic system. In its turn, the second concept represents the actual practice of a natural language by native speakers in real-life situations: any communication using this language may exhibit speech errors and idiolects, which should have a plausible explanation because people usually know the grammar rules of their dialect. Precisely, there is always a *context* enabling a particular performance.

Context is the structure of active relations surrounding a type of linguistic event and influencing its next outcome. The observable linguistic output of the native speaker also reveals the use of the rules of the grammar, but under the influence of the individual context, in which a configuration of biological, social and cultural conditions become manifest. In order to infer the grammar rules and to describe the linguistic competence, one must assume that divergences between competence and performance may happen due to the contextual conditions in a specific empirical setting. The context becomes manifest on the chain of symbols that is the outcome of the ongoing linguistic process.

The dichotomy between the concepts of competence and performance resembles the way of studying the firm (Lawson, 1997): the hypothetico-deductive, rational approach relying on Social Positivism and the retroductive, relativist approach relying on Critical Realism happens in works of this discipline. Like in language, competence is always independent of performance in the firm. While competence is the formal system of rules to generate valid chains of decision-making events, performance is any sequence of event outcomes observed in a specific empirical setting, which also involves additional knowledge about the context in which this specific process instance is being developed.

The present paper proposes a formal model for the firm. On the one hand, there is the econometrics' modeling approach to investigate governance structures relying upon the assumptions of Social Positivism and techniques of statistics. On the other hand, there is the generative linguistics' modeling approach to investigate social processes of governance relying on the assumptions of Critical Realism and techniques of computer science. The next section explains how this modeling approach applies to the design of empirical research targeting a new theory of the firm.

2.3 A Generative Model of the Social Processes in the Firm

In Generative Grammar Theory, Noam A. Chomsky (1956) introduced a hierarchy of classes of formal languages that is consistent with increasing levels of computational complexity for the recognizing automaton. The *regular grammars* describe the class of the languages with the lowest level of com-

plexity, which only have left (or right) *linear rules*, i.e., A → a, B (or A → B, a) and *terminal rules*, i.e., A → a. Next, there is the class of *context-free grammars*, in which at least one *recursive rule* takes place, i.e., A → B, C. Finally, there is the class of *context-sensitive grammars*, in which at least one *strictly context-sensitive rule* takes place, i.e., A, B → A, C. The Chomsky's hierarchy of grammars is equivalent to the hierarchy of automata based on the classical model of computation (Church, 1937; Turing, 1936), which is still in use in the field of Formal Language Theory.

This work assumes that the market and the firm are economic adjustment systems behaving like an automaton, and proposes explaining these social systems within their empirical settings based on a category of social process: an abstract category mapping objects and morphisms into a set of alphabet symbols for all known outcomes of types of decision-making events and into a set of grammar rules for known state transitions in the social system, respectively. Each event outcome follows another in such a stable, sequential pattern over time, and has a terminal symbol attached to it, approaching the methodological approach used in generative linguistics. In this sense, a social process is a pattern of derivations of valid sequences of symbols relying upon the rules of a grammar. If this is a valid assumption, then two systems sharing a common structure are comparable between themselves in terms of the patterns of event outcomes they are capable of generating, and of the similarities and differences in their corresponding sets of rules. In addition, both them will exhibit the same level of computational complexity.

The proposed grammar model acknowledges the neo-classical assumptions of profit maximizing behavior and perfect knowledge under the notion of *competence* borrowed from generative linguistics, but it still considers the criticism of the behavioral approach to the studying of the firm, assuming satisficing behavior and bounded rationality under the notion of *performance* (Cyert & March, 1963). Each assumption is detailed in the sections below.

2.4 Left Linear Rules in the Contract-based View of the Firm

By the assumption of "perfect knowledge," the contract-based view of the firm states that all information required for the decision about the internalization or externalization of an economic activity (i.e., "make" or "buy" outcomes) is available to the firm. As an atomistic model of action, each decision-making event is independent from all others before it, and the sequence of event outcomes exhibits such a regular pattern, which is acknowledged by a finite automaton. In the terms of Automata Theory, this means that the model is "memoryless." Each state of the system of economic governance means how

efficient is the configuration of internalized and externalized activities in the firm at the present time, such that each new decision outcome can either increase or decrease the efficiency of economic coordination in the firm.

The production rule linking a pair of chronologically consecutive system states (e.g., A and B) is a left linear rule (i.e., A → a, B), which represents one of the two possible event outcomes (i.e., "make" as a and "buy" as b). Using this rule means that the event outcome relies only on the existing conditions in a given system state (A) to make that state transition (to B). There is no sense of using a right linear rule (i.e., A → B, a) because the first system state chronologically precedes the second one; that is, the n^{th} event outcome (a) occurs only after all other n-1 preceding events had already occurred, such that no type of process going to be developed (i.e., a sequence of event outcomes yet coming into being) must be allowed before the present event outcome. In addition, the coordination function is such a linear relation between the initial configuration of economic activities under either bureaucratic or market governance and the resulting one (e.g., between the states A and B) right after the choice about the internalization or externalization (i.e., a or b) of a specific activity occurs.

Consistent with one of the branches of the contract-based view, if markets and firms are functionally equivalent structures of coordination, then they are at the same level of computational complexity, that is, they can acknowledge the same class of patterns of sequences of events. Since decisions of economic agents are independent of all others in the market, it is a "memoryless" social structure, and the firm is also.

Assume now the advantages of the firm over the market go beyond the minimization of costs of atomistic transactions. In this case, there is at least another kind of structural relation in the sequences of decisions of the firm that is absent in the market. Thus, the computational complexity of the grammar for this relation is greater than the regular, which is the only possible class in the contractual view, that is, at least one rule is not left linear nor terminal. The sections below argue why there are relations with higher complexity levels in all forms of governance structures other than the market.

2.5 Recursive Rules in the Competence-based View of the Firm

The development of the coordination process in the market is a consequence of the price-based adjustment system but without the awareness of the economic agents. In its place, the coordination function exerted by the firm comes from the bureaucratic system with the intention of the social actors, which Coase (1937) called the "entrepreneur-coordination." Consequently, the firm can plan ahead a sequence of actions which are necessary to achieve a

goal, but in the market, events take place stochastically, that is, by means of a random process.

In both in the firm and in all other non-market forms of economic governance, the coordination function takes place as a sequence of decisions of one or more actors that may influence future decision outcomes over time. When a sequential configuration of events determines an event outcome going to happen in the future, *time* becomes a key dimension and the unit of analysis must not be single decision-making events, but the entire pattern of sequences of events, which is the notion of a category of social process.

The firm in search of an opportunity to create a new source of rent by means of innovation is exercising such an entrepreneurial competence in way that is still specific to its evolutionary trajectory (Knight, 1921). This trajectory is the result of the dynamic and transformative role of the organizational knowledge that takes place in *routines* (or *capabilities*) – the productive skills of the firm (Nelson & Winter, 1982).

Inside the firm, the coordination function occurs as a social process in the search for configurations of productive capabilities that together are economically valuable by the means of high interdependence and tight coupling between them; nonetheless, taken in isolation, they still cannot create economic value. The decisions of the firm combined into such a coherent, continuous problem-solving process take place through the actions of a stable group of actors. In this sense, since collective decisions may take place, there is still a distributed decision-making process between the enrolled social actors, which internal state changes over time through the change in the internal states of the actors themselves.

The capabilities and routines change over time through learning. They apply to new competitive problems by the means of a new configuration of idiosyncratic resources resulting from new investments on specific relationships and admission of new people to the staff (Dosi, Teece, & Winter, 1992). The firm takes part in organizational learning spaces to increase the chance of achieving a satisfactory solution to their competitive problems. On the contrary, the lock-in effect of domain-oriented learning constrains the evolutionary path of capabilities and routines in the firm. Therefore, capabilities that make firms heterogeneous are often historically accumulated in their organizational surroundings from sequences of decisions about the deployment of resources.

Firms and markets apply to solve economic problems efficiently; however, they are structurally different such that both them are not functionally equivalent at all. On the one hand, perfectly competitive markets enable the competition process between firms, which is a massively parallel, linear search pro-

cedure based on the experimentation of variations of the sequential pattern of decision-making events to solve the problem. It is possible due to simultaneous, non-related decision-making processes at rival firms. Each firm is either in or out of the market space, in the last case after a certain threshold of allocative inefficiency has been reached for the first time. Thus, markets can explore candidate solutions at an exponentially higher rate than firms can ever do. On the other hand, the firm performs a divide-and-conquer, recursive search procedure based on the experimentation of different sequences of decision-making events to solve the problem. Thus, firms can prospect candidate solutions by trial-and-error. To put it briefly, firms and markets are distinct approaches to the same goal, but by different means, such that their sets of valid solutions are not the same at all.

In addition, the cost of solving competitive problems within the firm is usually lower than the cost of selection and elimination of chronically inefficient firms by the market. The market is a brute-force-based, concurrent selection mechanism over the domain set of candidate solutions using the competition process, which is more expensive than the heuristics-based, serial experimentation mechanism over the domain set of candidate solutions using the competence development process in the firm. However, markets and firms have no guarantee of success in finding either an optimal or even a satisfactory solution – there is always a level of uncertainty about the outcomes of the coordination function.

The main criticism of the competence-based theorists is about the incompleteness of contracts. They are incomplete because of the complexity and unpredictability of the production; mainly because of the missing knowledge the firm is going to learn, which is mostly unforeseeable (Hodgson, 1998a). Production outcomes are uncertain and the contracts cannot anticipate all future outcomes. In this sense Knight (1921) argues that the key role of the firm is to cope with uncertainty: bureaucracies can prevent and even correct any trajectory of negative outcomes leading to the failure of the firm in market competition, which is also cost-saving.

Recursive relations are necessary to modeling the coordination function inside the firm because of uncertainty. The main example of recursion in a firm is its hierarchical structure, by which the goal is to manage the complexity of the coordination function. The division of labor enables the continuous improvement of productive capabilities and development of competence through a process of learning (Grant, 1996). Single, self-employed contractors buying and selling products and services in the market can randomly increase their productivity and economic growth, but firms deliberately make this evolution-

ary path faster and cheaper than the market can ever do – by developing social processes with increasing complexity in order to cope with uncertainty.

The recursive rules occur in grammar structures yielding many patterns of sentences belonging to a formal language. When a rule activates at least a pair of rules in its right side, the resulting grammar make “infinite use of finite means” (Chomsky, 1965). It is also valid to firms, which are hierarchical social structures coordinating tightly coupled productive activities based on a deliberate, recursive social order; in contrast, markets are flat social structures that coordinate loosely coupled exchange activities between firms based on an emergent, random social order. Each process in the firm comprises a pair of sub-processes recursively, exhibiting the property of path-dependence.

A pair of chronologically consecutive decision-making processes needs a recursive rule (i.e., A → B, C): the expected process (C) relies on event outcomes yet come into being (B), which depends on conditions not available in the current system state yet. In other terms, there is a subsequent process (C) that cannot be realized until the preceding process (B) has been fully realized. There is high uncertainty about the realization of the subsequent process (C), such that other alternative rules (i.e., processes) may still exist, which are other rules with A in the head. Uncertainty ends only after every earlier event outcome has already occurred (i.e., the complete realization of B). This process requires a structure of coordination at a higher computational complexity level than that of the regular languages, to which the market is constrained.

Considering the analytical model of economic governance structures deduced from the Generative Grammar Theory, the social processes of competence development and inter-organizational relationship are patterns of sequences of decision-making events that only firms and other non-market forms of economic governance can handle. This is a distinguishing characteristic of these governance structures; however, it is not the only one: the firm still exist to grasp the context in which they operate to reduce the uncertainty about future developments.

2.6 Context-sensitive Rules in the Systemic View of the Firm

Firms often pursue goals that appear to make no economic sense; nevertheless, they continue to exist and to evolve over time. Of course, firms eventually make mistakes because of uncertainty and bounded rationality (Simon, 1976), but it is not the case when there is a context supporting the rationality of a type of action that a real economic agent repeats over and over again.

The assumption of *contextual rationality* means one does not need to be conscious nor completely informed of the determinants and consequences of his actions (March, 1978). The context in which the action takes place pro-

vides the meaning of rationality. In addition, if the context often evolves over time, then there is a temporal dimension of rationality. Both the determinants and the consequences of each action exist before it takes place in an empirical setting; nonetheless, social actors may not be fully aware of them at least until then. If there are enough empirical data to analyze, then inductive inference of the context is possible as a type of action repeats over and over again in the same social system and in the same empirical setting: configurations of past event outcomes underlying the structure of a category of social process are evidence of the decision function that is effectively in use.

Assume now that organizational knowledge is a kind of emergent property of groups rather than an aggregation of the knowledge of their members; it is meaningful through the social relationships that the individuals hold with each other in the context in which they exist together. It is an epiphenomenon of the social interactions between actors embedded in a complex of structures of social nature, which co-evolve over time. This is knowledge learned through imitation and trial-and-error actions in search of solutions to a competitive problem that exists in the empirical setting of the organization. There is the need to recurrently exploit specialized services from knowledge to preserve its value, but the value of knowledge is restricted to the context in which it is produced as well (Hodgson, 1998b).

All productive skills are tacit, idiosyncratic and unmeasurable. For Knight (1921), there is no such “complete market” of entrepreneurial and managerial skills. In addition, knowledge cannot be bought as required, in contrast with the belief of Coase (1937). There are adaptation costs for transferring intangible resources from one social system of production to another, which makes them non-transferable in practice. The value of intangibles cannot be known in advance until their implementation in the context of the productive system. In face of a high level of uncertainty, competence can neither be bought nor be readily developed in the market (Teece & Pisano, 1994). The recognition of the influence of the context on the rationality of the actions of the firm highlights the problems of interpretative ambiguity and divergent cognition, which are often ignored by many of the theoretical views of the firm (Hodgson, 1998a).

In fact, *ambiguity* is the property of a logical statement whose meaning cannot be resolved by a finite number of steps; it is a state of uncertainty in which more than one interpretation of the meaning of the statement is conceivable. For instance, a piece of information is ambiguous whether it has different meanings in two or more different interpretations of the same situation.

Grammars are ambiguous if and only if there is at least one valid sentence with more than one leftmost (or rightmost) derivation path; it is a chain of symbols with more than one valid interpretation about belonging (or not) to a language. In contrast, unambiguous grammars must have one and only one derivation path for all valid sentences. In this sense, ambiguity can be eliminated by either adding precedence to the grammar rules or turning each set of alternative state-transition rules into context-sensitive rules; however, it is not trivial to detect ambiguity in grammars because it is an undecidable problem (Basten, 2009).

In a social process' grammar, the existence of ambiguity means that some instances have more than one valid explanation: these are considered as *multiple* or *competing explanations*, which indicates a weakness in the theory when explaining some outcome. However, the elimination of ambiguity from a grammar for a theory needs substantive knowledge, and then it cannot be automatized. If there is empirical evidence of the effect of the context on the idiosyncrasies of the behavior of actors taking part of a process, then the researcher rejects the hypothesis that this structure is representable by either a context-free or a regular grammar. The process under inquiry is contingent upon a configuration of contextual conditions.

The epistemological paradigm of Critical Realism, as opposed to Social Positivism, contemplates contradictions in the scope of science, that is, it can accept a surprising fact that contradicts the prediction of the currently most accepted theory. The criterion to assess the *scientificity* of some theoretical statement about the anomalies in a social phenomenon is not the logic of falsification, but the logic of retroduction. This research approach comprises the empirically grounded refinement of a formal model to explain all the observed contradictions based on the influence of the historical context.

In the social sciences, any contingent feature of a social system can be learned from qualitative data about social outcomes in an empirical setting. Thus, a configurational approach to inquiry relying on Set Theory must replace the statistical approach relying on Probability Theory (Ragin, 1987). Because Formal Language Theory is an extension of Set Theory, configurations of contextual conditions can still map to an index symbol ([K..]) used in an indexed grammar (Aho, 1968). Adding a new event outcome for the surprising fact in the grammar is the same as adding an alternative state-transition rule: it excludes the complement set with regard to the domain of the original rule (i.e., $A \rightarrow B \mid B'$, where $B \cap B' = B$). Nevertheless, the new rule introduces ambiguity since B' is currently read as B, but these events should be mutually exclusive (i.e., $A \rightarrow B \mid B'$, where $B \cap B' = \emptyset$). In order to eliminate ambiguity, the procedure of retroduction turns a set of alternative

rules triggering contradictory interpretations of an event outcome into mildly context-sensitive rules (e.g., both $A[K_{B'}..] \rightarrow B'[..]$ and $A[..] \rightarrow B[..]$, or even $A \rightarrow B$ with less precedence). This procedure brings the non-terminal symbol for another new outcome of an earlier type of event back into the derivation path, which pushes the contextual condition as a symbol onto the index stack (i.e., $C[..] \rightarrow D[K_{B'}..]$).

Thus, the computational complexity level of contingent developments acknowledges context-specificities of real-world social phenomena, including the firm. In this sense, many middle-range theories of the firm can co-exist regarding the types of surprising event outcomes that may be generated in some empirical settings. In the section below, the epiphenomenon of the contribution of the firm in terms of capabilities and economic goods in the benefit of its socioeconomic system is discussed as an example of this kind of retroductive research approach resulting in specialized categories of social processes.

3 Conclusions

The goal of coordination in the firm is to achieve higher computational complexity levels than the market is capable of doing. Both capabilities and competencies cannot be fully integrated into the markets; it is due to their recursive and context-sensitive properties. The process of resource deployment in circumstances of high uncertainty is inherently complex. The behavior of an economic agent consists of a procedure with various actions and interactions attempting to create new sources of rent through both the deployment of resources and the generation of economic goods.

Instead of being a production function, the firm is a heuristic for innovation, but the firm cannot provide a solution for some competitive problem, which is still valid in all conceivable empirical settings, in one shot – time and space become key dimensions. In addition, competence is not contractible, but the contractual view of the firm ignores the possibility of non-contractible activities in the productive process. In a production system where all knowledge can be bought as required, there is the need to anticipate which knowledge will be required in the future yet. Nevertheless, the anticipation of the consequences of actions is possible due to the recursive organization of firms and all other non-market forms of economic governance, and the reduction of uncertainty is possible due to their context-sensitiveness, but these properties are completely absent in the market.

The organizational structure captures past experiences of the firm to fore-

cast actions that are related to a satisfactory outcome to be implemented in a future situation, instead of building up the solution for a competitive problem from scratch using the brute-force approach of the market mechanism. Knowledge the firm learned a long time ago while developing a capability or economic good may now turn out to be the context enabling a new project. Nevertheless, this specific course of action is not possible in other firms lacking the same experience, that is, the same order of event outcomes, because these configurations of contextual conditions differ in respect to causal powers.

These conclusions are not new at all, but the phenomenon of economic governance still requires a formal model of explanation acknowledging its complex, dynamic and contingent features. However, the choice of a model for scientific inquiry should always require to match its mathematical properties with the ontological and epistemological assumptions of the adopted philosophical stance: it is necessary to produce a legitimate understanding of the phenomenon. For the Theory of the Firm, this work has aligned the assumptions of Critical Realism with the properties of Generative Grammar Theory. Here, the researcher still has to choose the grammar formalism that is adequate for the theoretical perspective of the phenomenon in use as well as the empirical setting under inquiry. There is a trend towards the coexistence of middle-range theories and the shift from “pure” to hybrid models of the complex, dynamic and contingent phenomenon of economic governance. This kind of research approach relying upon the techniques of generative linguistics may become a *categorical-generative revolution* in heterodox economics, management and other social sciences in general much like the marginalist revolution which originally took place in the neoclassical economics.

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