# The Generative Nature of the Firm

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**Abstract.** This paper discusses a meta-theoretical framework that aims to explain all forms of economic coordination using a computational complexity approach. Using a formal model inspired by Generative Grammar Theory, it establishes a demarcation criterion between markets and hierarchies (including hybrid forms). The hypothesized equivalence between economic coordination structures and linguistic structures makes it possible to explore any sequence of decision-making event outcomes, whether individual actions or social interactions, for patterns of causal relations in a way analogous to sentences in a language. This research concludes that patterns of decision-making events are categories of processes, and that economic coordination in organizational structures achieve a complexity level that is not possible in free market structures.

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**JEL Classification:** D21, C63, L25

## 1 Introduction

Many economists have written about how market economy is superior to the central planning economy. Friedrich Hayek (1973) argued for the importance of market prices in signaling information about scarcity and demand to buyers and sellers, which enables them to make efficient resource allocation. In his view, the decentralized nature of the supply-and-demand adjustment system of the markets allows economic agents to use their local knowledge to make informed decisions that improve economy. In contrast, the centralized nature of the command-and-control adjustment system requires a single entity with complete knowledge of all available raw assets, productive capabilities, and consumer preferences to make informed decisions about resource allocation, which seems impossible. Nonetheless, neither bureaucracies nor markets are perfect. Other economists, such as George Akerlof, Joseph Stiglitz, Paul Samuelson, and Ronald Coase, have warned about market failures, such as market power, information asymmetries, under provision of public goods, and externalities. They doubt whether markets can ensure that prices reflect all available information, which is necessary for efficient resource allocation. Consequently, institutions and government intervention are often necessary to prevent negative outcomes from market failures (Stiglitz, 1985).

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Similarly, many economists emphasized the capacity of markets to deal with distributed information that firms would not possess. However, since firms function as central planners for the production of goods and services, and cannot outperform the market, then why do firms exist, expand, and multiply over time rather than relying solely on markets?

The theory of the firm is the field of social research concerned with answering not only the question above, but in fact a range of questions. Firstly, "why do firms exist?" is about the *existence* of the firm. Secondly, "which economic activities are internalized in the firm, and which are transacted in markets?" is about the *boundaries* of the firm. Finally, "what are the determinants of an efficient economic coordination?" is about the *performance* of the firm.

Neoclassical economics introduced the first theory of the firm, which aims to explain the behavior and decision-making of firms in a market economy. Based on this theory's assumption of perfect competition, firms operate in a free market where competitors make decisions based on price and demand. In this scenario, firms are "price takers," because they have no control over market prices, which the forces of supply and demand determine. Therefore, firms' survival requires efficient production. Additionally, firms can always minimize costs by choosing the most efficient method of production, based on the available technology and market prices. This approach reduces the firm to a "production function," which describes the relationship between inputs and outputs and exhibits diminishing returns to scale. This means that as the firm rises its output level, the marginal productivity of inputs decreases. Consequently, the goal of the firm is to determine the production level that maximizes profits by offering goods and services that consumers will buy at a price higher than the cost of production.

From the assumption of perfect competition, this view proposes that two features are common to all firms. First, *profit maximization*, which is the statement that firms always pursue the largest gap between revenues and costs, in a way that is similar to the utility maximization assumption from microeconomics. Second, *perfect information*, which is the statement that economic agents have complete and accurate information about both the market and the goods and services traded on it, which includes the price and quality of the products as well as the availability of substitutes. Consequently, this view of the firm proposes a rational-agent model for the analysis of economic behavior.

Despite the apparently sound set of assumptions and propositions, the neoclassical theory of the firm has difficulty explaining why firms exist and take distinct forms, but Ronald Coase proposed an alternative answer to these questions in the seminal paper "The Nature of the Firm" (1937). According to his argument, when purchasing goods and services through markets, transaction costs are always involved. These costs can occur both before the exchange takes place, such as searching for the best offer and formulating a contract, as well as after the exchange, such as evaluating the outcome and enforcing the contract. On the other hand, when using organizations to make them internally, minimization or elimination of transaction costs is possible. Ronald Coase also proposed that the size and scope of the firm results from a trade-off between the bonus of reducing transaction costs and the onus of increasing administrative costs. Consequently, the decision criterion to make goods or services within a firm rather than buy them in the market is minimizing the costs not related to producing them.

The Transaction Costs Theory proposes that there are frictions (e.g., incomplete and asymmetric information, uncertainty about future) in real markets, which then make the coordination of economic activity by means of contracts less efficient than what it could be whether the transaction costs for firms to engage in contracts with other parties were negligible. This came to be the theoretical foundations of the paradigm for the studying of the economics of organization known as the *contractual* view of the firm (Alchian & Demsetz, 1972; Williamson, 1971, 1975).

The contractual view proposed many criticisms to the neoclassical view of the firm. Firstly, while the former view assumes that all parties have perfect information, which means that they have access to all information about a transaction, they frequently have *information asymmetry*, which means that some parties have more information about the transaction than others do. Second, the former view assumes that contractual clauses specify all possible outcomes and contingencies in advance, but there are often only *incomplete contracts*, such that unexpected events may regularly arise. Finally, the former view assumes a separation between the owners and managers of the firm who act on their behalf by means of incentives, but managers may pursue their own interests at the expense of the owners, which implies in *agency costs* and lower profits afterwards.

The contractual view became the dominant theory of the firm in economics, as is evident by the fact that it has received three Nobel prizes in the field: Coase (in 1991), Williamson (in 2009), and Hart and Holmström (in 2016). These and other authors promoted a shift from focusing on issues related to the firm's actions in its many markets, such as pricing outputs and combining inputs, to issues related to the internal organization of the firm, such as its nature, limits, and efficient functioning.

However, the relationship between the neoclassical and the contractual views of the firm is not solely of disagreements. The contractual view actually acknowledges several neoclassical assumptions, such as the presence of rational agents, resource constraints, market efficiency, and well-defined property rights. The contractual view still seems as an extension of the neoclassical view, rather than a challenge to it. Consequently, any alternative view of the firm that seeks to compete with the contractual view has taken a critical stance against the notion of the firm as a "nexus of contracts," rather than against the neoclassical notion of the firm as a "production function."

One of the earliest challengers to the neoclassical view, the *behavioral* view of the firm (Cyert & March, 1963; March & Simon, 1958; Simon, 1947, 1955) proposes to explain the individual behavior within the firm based not only on the assumption of self-interest, but also on psychological, social and institutional issues, replacing transactions with decision-making processes as the unit of analysis. This theoretical approach begins with the criticism of two assumptions of the neoclassical view: *profit maximization* and *perfect information*. Consequently, the behavioral view assumes that every economic agent exhibits *bounded rationality* due to limited information access and processing capabilities, such that decision outcomes are only satisfactory rather than optimal.

The importance of the field of behavioral economics was recognized by the Nobel Prize awarded to Herbert A. Simon (in 1978) for his research into the decision-making processes within economic organizations, followed by awards to Kahneman (in 2002) and Thaler (in 2017). Nonetheless, the dominance of the contractual view in the field

of the theory of the firm persists, at least among mainstream economists. In strategic management and organization studies, the behavioral view reached significant influence, such that other theories of the firm arose against the contractual view relying on some assumptions of the behavioral view.

Other challenger, the *resource-based* view of the firm (Penrose, 1959; Wernerfelt, 1984), or simply RBV, proposes to explain the growth of the firm based on the analysis of productive activities, replacing transactions with factors of production as the unit of analysis – the firm as a "bundle of resources." This theoretical approach also starts with the criticism of a pair of assumptions of the neoclassical view. First, it rejects *perfect competition*, which is the assumption of an ideal market structure where the interplay between supply and demand determines prices. Second, it rejects the *market efficiency*, which is the assumption that prices accurately reflect all relevant information about the traded assets.

Industrial Organization, a field of economics that has neoclassical roots and is another target of the criticisms of some branches of RBV, also leaves behind these two assumptions when acknowledges the possibility of competitive advantage based on industry structure and monopolistic competition. RBV also acknowledges the prospect of *competitive advantage*, but relies on non-tradable, rare, inimitable, and non-substitutable resources, which have strategic meaning only to the firm in which they are deployed (Barney, 1991; Peteraf, 1993). Consequently, there is more than one resource-based view of the firm, each focusing one type of resource, such as productive knowledge (Grant, 1996) or inter-organizational relationships with other firms and supporting institutions (Dyer & Singh, 1998).

The book "An Evolutionary Theory of Economic Change" by Richard Nelson and Sidney Winter (1982) has played a critical role in redefining the resource-based view. Inspired on Cyert and March (1963), they argue that the competitive advantage of firms arises from *capabilities*, which is a specific class of resources relying on organizational knowledge in the form of *routines.* Nelson and Winter consider routines as the building block of organizations, and argue that these capabilities and routines evolve over time as a result of learning and experience. In this sense, these authors influenced two important branches of the resource-based view: the *competence-based* view (Prahalad & Hamel, 1990) and the *dynamic capabilities* view (Teece et al., 1997; Teece & Pisano, 1994).

The competence-based view argues that the sustainable competitive advantage of a firm relies on its ability to develop and leverage its unique configuration of knowledge, skills, and intangible resources, called "core competence," which allows for the development of new products and services, entrance on new markets, and response to changing customer needs. In turn, dynamic capabilities are the firm's abilities to modify and adapt in response to changes in its competitive environment that take place over time, or precisely, the abilities to reconfigure its internal resources and capabilities, seize new opportunities, and overcome threats. Both the competence-based view and dynamic capabilities have become the major branches of the resource-based view of the firm in the literature of organization studies and strategic management. However, they have had little impact on the field of economics.

Since many of the assumptions of these views of the firm contradict each other, they

still cannot provide definitive answers to the key questions that could establish one of them as the ultimate theory of the firm. This research project questions if it is possible to conduct research about the firm using the existing approach, and if not, whether another theory of the firm is necessary. Meanwhile, this paper discusses propositions from the research project it is a part of, with the aim of formulating an alternative approach to studying all forms of economic coordination from a meta-theoretical perspective.

## 2 The Problem of the Nature of the Firm

According to Hayek (1973), the deliberate nature rather than the emergent nature of social order distinguishes the firm and the market, respectively. The markets are social systems that emerge spontaneously through the interactions of rational agents in a decentralized market economy. In contrast, the firms and other forms of organization are social systems designed to coordinate action and interaction among individuals, groups, and even other firms, whose preferences, information, interests, and knowledge may differ, but which have to pursue a specific common goal, such as maximizing profits or accomplishing a social outcome. In this way, markets have no other mission or purpose besides coordinating the exchange of goods and services between individuals and firms.

The mainstream economists put markets and firms at the extremes of a continuum of structures for decision-making about resource allocation. In perfectly competitive market structures, economic coordination takes place through a decentralized system of interactions between independent buyers and sellers who make choices in their own self-interest, guided by price signals created by a supply and demand mechanism. In hierarchical and hybrid forms of organization, economic coordination occurs through a centralizing system of interaction between interdependent economic agents who make choices in the benefit of the organization as whole, guided by rules, standard operating procedures, and a chain of authority created by a command and control mechanism.

The alignment of decisions to manage dependencies between productive units occurs either in the firm or in the market. If the outcome of an economic activity relies on another decision made previously, then both are interdependent, even if there are no administrative couplings between them. Therefore, markets cannot eliminate the level of interdependence between buyers and sellers, but they minimize the level of coupling because each buy or sell decision has nothing to do with the others, except when contracts specify otherwise. The deliberate increase in the level of coupling between interdependent activities or decisions only takes place in firms and other organizational forms of economic coordination (Siggelkow & Rivkin, 2008). Administrative coupling between decisions takes place only if agents in charge of them are in touch and have a kind of "memory" of what they are planning to do in the future. In other words, centralized or hierarchical decision-making occurs through an increased level of coupling between interdependent economic activities. In this sense, markets are "memoryless" structures.

In synthesis, markets are often better suited to situations where there are many small-scale economic agents with diverse interests, while organizations are often better suited to situations where there are large-scale, complex economic activities. However, there

is no single grand theory to explain this, but many concurrent theories relying of distinct and often contradictory assumptions, which seem irreconcilable at first glance. In fact, some of these theoretic views, when integrated in a middle-range theory (Merton, 1968), often provide more realistic explanations and predictions about the behavior of the firm regarding their specificities in real situations than each of them taken alone.

The present research project proposes a meta-theory to reconcile alternative theories to explain the firm, relying on a social ontology that undertakes the generative nature of the social processes that constitute them (Braga, 2017b, 2020). In this sense, the goal of this paper is to discuss the assumptions of this meta-theoretical framework to define a demarcation criterion between the market structure and other coordination structures, including the firm, using a computational complexity approach. The following sections discuss some of these assumptions in detail.

## 3 Theoretical Assumptions for Modelling Propositions

Simon (1947) stated that decision-making is central to administration, but it is often constrained by factors such as limited information, bounded rationality, and satisficing behavior instead of complete information, perfect rationality, and maximizing behavior. For him, the assumption of rationality implies the perfect knowledge and anticipation of the consequences of each course of action, but this is not what real decision-makers do. Cyert and March (1963) agreed with him when argued that studying empirical deviations from the neoclassical model of rational agent is not a recommended because of the unrealistic assumptions it makes.

Simon instead suggested that the understanding of organizational behavior requires an understanding of individual behavior, such that the adoption of theories and methods from behavioral psychology could lead to more realistic administrative research. In this way, he once said that the "vocabulary of administrative theory must be derived from the logic and psychology of human choice" (1947, p. xlvi). Similarly, Cyert and March (1963) proposed a new foundational set of assumptions that allowed the development of the behavioral view of the firm, which assumes a pretentiously rational-agent model and relies on principles of behavioral psychology, especially those related to heuristic decision-making and cognitive biases.

Behavioral psychology, or *behaviorism*, is the study of observable behavior as consequence of the interaction of an individual with its external environment through the operation of conditioning mechanisms such as reinforcement and punishment. Born at the beginning of the 20$^{th}$ century, the assumption that behavior is learned through experience and subject to modification by antecedent stimuli, such as positive and negative reinforcement, shaped this discipline. In this way, behaviorism assumes that individuals are born without any inherent knowledge or predispositions, and that learning, viewed as the association of external stimuli and responses, shapes the childlike mind as if it were a "blank slate". Since the mind's internal mechanisms involved in the process of learning are unobservable, behaviorists not only assume them outside of the scope of science, but also non-existent, or equally available to all individuals.

In the 1950s, some critics of behavioral assumptions initiated a movement called

*cognitive revolution*, which proposed the modularity of mind, the mediation of sensory input by innate information processing systems, and the adoption of scientific methods to study cognition. As the result of this break from behaviorism during the 1960s, cognitive psychology became the studying of the mind and mental processes, such as attention, memory, perception, creativity, reasoning, problem-solving, and language use. In addition to this field, cognitive science emerged as the interdisciplinary study of the nature and functioning of cognition in a broad sense, which is not restricted to the human brain but includes non-human specimens and artificial intelligence. There is much in common between these two fields concerning the study of human cognition, except that cognitive science admits contributions from other fields of human knowledge, such as computer science, linguistics, neurology, and sociology.

Many cognitive psychologists have contributed to the study of decision-making processes. Tversky and Kahneman developed research comparing cognitive models of decision-making with the rational-agent model, demonstrating that people often rely on mental shortcuts or heuristics, leading to systematic biases and errors of judgment (Kahneman, 2002). Even Simon, who was not psychologist, is one of the pioneers of this field. However, Noam Chomsky, a major figure in the development of modern linguistics, is the man who started the cognitive revolution with his critique of behaviorism (1959), which defined behaviorist and cognitive stances as *empiricist* and *rationalist*. In other words, the former stance assumed that language acquisition occurs only through sensory input, whereas the latter proposed that an unobservable innate linguistic system exists mediating learning and external stimuli.

In his work, Chomsky questioned how children could acquire language despite relatively limited input, arguing the existence of a specific innate learning mechanism, or a biological faculty for processing sensory input and coercing natural languages to particular types of grammars, which he called the "poverty of stimulus argument." Moreover, despite his contribution to the development of cognitive psychology, another work by Chomsky has had an impact on this discipline as well: the Generative Grammar Theory.

Chomsky founded the field of generative linguistics, which studies the knowledge of the speakers of a language as a linguistic system used to produce grammatically valid sentences based on an innate, universal set of rules and principles that are common to all human languages. In Generative Grammar Theory, Chomsky suggests describing the knowledge of a speaker of a language and the innate linguistic faculty of the human mind as a set of rules and logical operations known as *generative grammar* and *universal grammar*. The set of grammar rules can describe the structure of grammatical sentences in a language, or more specifically, the way that words combine to form phrases and sentences, such that meaning results from grammar usage.

Generative linguistics asserts that people produce an infinite number of sentences in their language using a finite set of rules and words, based on the assumption of universal grammar, which is the hypothetical cognitive mechanism of the human brain or the biological and computational basis of linguistic competence. Despite being a work in the field of linguistics, the book "Syntax Structures" (Chomsky, 1957) has had a significant influence on cognitive psychology and science. In reality, the propositions of this research project rely largely on this book and Chomsky's critique of behaviorism.

Although Chomsky (1959) rejected both the behaviorist and empiricist assumptions in his seminal work that established the foundations for cognitive psychology, Foss and Felin (2009) argued that these assumptions are in the base of the research on both the behavioral and resource-based views of the firm. Like Chomsky, these authors argued for cognitive and rationalist assumptions to explain the phenomenon of organization, with which this research project agrees.

According to behaviorists, external stimuli determine the output behavior. In this model, input factors include individual perception, observation, experience, and the environment, which is known as the *input-output* system, or model. Beliefs and expectations are considered a function of individual past experiences, which are shaped by continuing exposure to sense perceptions and observable environmental contingencies.

March and Simon (1958) and Cyert and March (1963) explicitly agree with the behavioral psychology model when they propose tracing organizational activity back to an environmental stimulus and describing the process of learning by experience within the environment using simple behavioral rules, respectively. Nelson and Winter (1982) also reveal behaviorist assumptions when define routines as a pattern of behavior that is followed repeatedly.

There is nothing wrong with the input-output model *per se*, but it implicitly assumes homogeneous economic agents in terms of internal properties and mechanisms. It also postulates a strong, deterministic relationship between inputs and the output of interest that is often empirically refutable. In addition to affecting outputs, inputs may also determine these internal properties and mechanisms. This is similar to considering the human mind as a "tabula rasa," or "blank slate." Consequently, it is impossible to explain heterogeneity in output properties or behavior using the behaviorist model. Chomsky (1959) rejected this model using the "poverty of stimulus" argument, to which this research project also agree.

Considering the rejection of the behavioral assumptions and the input-output model, which considers observable behaviors and their relationships with external stimuli only, there is a need for an alternative methodology for studying organizations. Felin and Foss (2009) recommends the cognitive psychology approach, which takes the internal mental mechanisms underlying behavior as the object of study, focusing on the way that perception, memory, attention, and reasoning shape individual behavior. The cognitive approach acknowledges that individuals process information from their environment to make decisions that guide their behavior, while also considering the individual differences in terms of cognition, prior knowledge, and motivation.

For the study of organizations, the level of accumulated experience or recurrence of behavior is no longer relevant. Instead, the ability to accomplish a task and repeat it is the object of attention. Felin and Foss (2009, p. 10) recommended that the "initial conditions and characteristics, choices, nature and abilities of the individual or organization itself should be studied rather than the experiences themselves, which may be epiphenomena (…) experiences (and their repetition) are used as empirical proxies." However, these authors caution that this approach does not explain the heterogeneity that often emerges in the output properties or behavior for many instances of the phenomenon.

This research project partly agrees with Felin and Foss' criticism. Social forms, such

as capabilities and organizations, are intermittent, transitory, and non-coherent artificial forms of "life." Consequently, they do not exist in the same way as biological forms of life. However, what these two authors suggest as replacement for the behavioral methodological approach used in the two leading alternative views of the firm is highly speculative, as the normal science methods of inquiry are not applicable to emergent properties and behaviors that are outputs of complex social phenomena. Of course, organizations are not "black slates," since people build them based on their beliefs and expectations about what the real economy is and how it operates. However, organizations are not people, and people working on them are no more relevant to studying than routines. The object of study should be to explain these patterns of behavior in specific empirical settings. In this sense, this project argues that generative social science, instead of cognitive psychology, provides a more realistic foundation for studying organizations and strategy.

This research project proposed to substitute the inquiry about relationships between measurable properties using the logic of refutation with the inquiry about mechanisms among event outcomes of either individual action or social interaction, which implies the adoption of an epistemology relying on a social ontology (Braga, 2017a). This paper does not discuss this epistemology, which is Pragmatist Critical Realism, or the proposed methodology, which is Categorical-Generative Analysis (Braga, 2023; Nellhaus, 1998). In the following sections, the discussion is about the theoretical assumptions of the proposed meta-theory for studying the firm and all hybrid forms of organization.

### 3.1 From Rule-based Behavior to Grammars of Action

Decision-making is the process of choosing a course of action among some possible alternatives relying on a predefined set of criteria for the evaluation of trade-offs, such as advantages and disadvantages, benefits and costs, as well as potential risks. It is the building block of daily routine for both individuals and organizations.

For neoclassical economists, decision-making entails a rational approach and relies on perfect knowledge, which generates an outcome based on the available information in a deterministic way. In this sense, there is no reason for a decision-making *process* under neoclassical assumptions because all economic agents are rational, have complete information, and make informed decisions based on their preferences and alternatives without any biases or constraints. However, in reality, individuals and firms face constraints and limitations that prevent them from making entirely informed, rational decisions. The process of structured decision-making is often necessary in real-life complex situations, and the building block of this structure is the concept of rule.

A rule is an instruction that informs a specific decision-making event and determines its outcome. It can be explicit or implicit, formal or informal, positive or negative. Formal rules can take on many forms, such as laws, procedures, and social norms. However, the primary purpose of rules is to ensure consistency, fairness, and safety in the situations in which they are applicable. Individuals, organizations, governments, or specific kinds of social structures have the power to create and enforce rules through various means, such as social pressure, legal sanctions, or incentives. The purpose of a rule

is to condition human behavior and ensure regularity and predictability in social interactions.

Rule-based behavior, according to Cyert & March (1963), is a pattern of decision-making that relies on a predetermined set of rules or standard operating procedures, which is established and executed in a consistent and systematic manner, often with little or no deviation. Typically, people use rule-based behavior in situations that involve well-defined procedures or require a high level of accuracy. However, rules can also have limitations, especially in complex or ambiguous situations that require flexibility and creativity, such as heuristic-based behavior.

Gavetti et al. (2012) argue that both individual and organizational behavior is driven by semi-automatic, habit-based decision-making processes, such as patterns of action. In other words, all individual and collective actions, including social interactions, are decision-making events. Contrary to the rationalist assumption, decision-making often takes place without fully explicit rational analysis of all available information. Decision rules require bounded flexibility in organizational choices, meaning that decision-makers must consider some, but not all decision criteria and alternative outcomes.

The concept of rule has had a significant influence on the development of theories in economics and management. Institutional economics recognizes that formal and informal rules, norms, and other institutional forms can shape the behavior of economic agents and affect the outcomes of their actions through incentives and sanctions. This field studies the rules established for economic governance, such as those governing the enforcement of contracts and property rights and the treatment of market failures. To understand the effects of institutions on economic performance, institutional economists consider the social, cultural, and historical context of economic activity. Institutional economists, from pioneers such as Thorstein Veblen and John R. Commons to Nobel Prize winners such as Douglas North (in 1993), Elinor Ostrom, and Oliver Williamson (both in 2009), have embraced this approach. This research project focus particularly on the work of Ostrom, as explained bellow.

Elinor Ostrom proposed analyzing the rules, norms, and shared strategies used for economic governance, particularly in the context of common-pool resources such as natural resources and their management systems. These resources are often prone to overuse and depletion due to individuals acting in their own self-interest, also known as “the tragedy of the commons.” Ostrom discovered communities around the world that had established rules and institutions for managing the use of common resources based on key design principles, including effective monitoring and enforcement, well-defined boundaries, and involvement of resource users in decision-making. She concluded that rules must be context-specific, flexible, and adaptable to the resource's characteristics and the community’s needs, evolving over time as initial conditions and circumstances change.

In the paper “A Grammar of Institutions,” Susan Crawford and Elinor Ostrom (1995) developed the Institutional Analysis and Development (IAD) framework to analyze institutional arrangements in the governance of common-pool resources. They argued that understanding the rules and norms that govern the use of these resources is necessary to design effective policies for their sustainable management. The grammar, within the context of institutions, describes characteristics of the governance system, such as

the roles of each actor, the patterns of their resource use, the rules governing their interactions, and the norms and values upon which their behavior relies. Additionally, grammars can systematically explain how institutions emerge, persist, and change over time under the influence of contextual conditions.

In the IAD framework, the metaphor of "grammar" refers to the set of rules that guide decision-making events about the use and management of shared resources. Numerous studies currently explore the use of grammars for analyzing institutions using the IAD framework. The Institutional Grammar Research Initiative (IGRI), established in 2018, serves as a repository of papers and research projects conducted by scholars interested in using a computational approach, such as supervised machine learning for data or text, to enhance the IAD framework. However, these works do not explicitly rely on Formal Language Theory.

Other authors explored the generative grammar model properly. Brian Pentland and Henry Rueter (1994) proposed a framework for analyzing non-repetitive organizational behavior using the principles of grammatical analysis. In their framework, organizations applied specific rule-based grammatical models to generate and interpret patterns of actions and interactions. They explicitly relied on Nelson and Winter's definition of processes but from an information systems perspective rather than an economic one.

In other work, Pentland (1995) cites the sociologist Andrew Abbott (1992, p. 428), and agrees that "social reality happens in sequences of actions located within constraining and enabling structures". He proposes to develop "the grammatical metaphor into a rigorous model for describing and theorizing about organizational work processes." However, he does not achieve this goal since he does not explicitly use Formal Language Theory in his works. While Pentland's analytical approach uses the definition of grammar as a construct to explore data and generate empirical findings in organizational practice, the usage of grammars remains merely metaphorical. All works in social sciences refer to grammars in this way instead of using them mathematically.

Considering the assumption that firms are social systems for establishing causal relations between their decision-making events over time, it is still necessary to demonstrate the ontological equivalence between linguistic structures and organizational structures. This question still resembles another older one, which is the equivalence between the coordination structures of the firm and the market. Both of them must have acceptable answers to make it possible to consider grammars as a formal model for decision-making processes, either in markets or in other structures of economic coordination.

The neoclassical economists assumed that markets and firms were equivalent, a view shared by some contractual view's authors such as Alchian and Demsetz (1972), but not by others such as Oliver Williamson (1975). Reducing economic decision-making to simply minimizing transaction costs ignores non-transactional and non-instrumental features of the firm. The contractual view also oversimplifies the problem of organizing by reducing it to independent, single choices for optimizing exchanges, overlooking the social processes involved in production, such as organizational learning and change. The assumption that all information necessary for decision-making is available to the firm implies that every decision-making event is independent of all others, before or after it, resulting in *stochasticity*. In the jargon of generative linguistics, this decision-

making process is “memoryless” and exhibits a regular language pattern (Braga, 2017b, 2020).

However, within non-market forms of economic coordination, decision-makers can deliberately establish a tightly coupled causal relation between some types of decision-making events. On the one hand, the firm plans a sequence of actions to achieve a future goal, which implies the property of *path dependence*. In the jargon of generative linguistics, this type of causal relation, in which there is a current event and a deliberate consequent event to occur in the future, is “recursive”, exhibiting a context-free language pattern. On the other hand, some decision-making event outcomes occur due to the influence of a specific ordered configuration of past event outcomes, which implies the property of *contingency*. In the jargon of generative linguistics, this type of causal relation, in which there is a current event outcome and a necessary antecedent ordered configuration of event outcomes, is “contextual”, exhibiting a strictly, mildly context-sensitive language pattern (Braga, 2017b, 2020).

In synthesis, the properties of path dependence and contingency only occur in social processes generated by non-market structures of economic coordination, such as the firm. In contrast, the property of stochasticity characterizes market processes, although it may also be present in social processes generated by other social structures. Different types of grammar rules apply to describe each kind of pattern of causal relations according to its computational complexity level: regular, context-free, and mildly context-sensitive. These rules describe causal relations between decision-making events or their outcomes, but do not necessarily correspond to the concept of rule from Cyert and March's seminal work (1963). The concept of rule used here has a broader meaning that allows for a wider range of applications, including the analysis of organizational routines.

### 3.2 From Individual Skills to Organizational Capabilities and Competence

The behavioral view of the firm adopts the concept of skills for analyzing individual behavior within the firm. In psychology, skill means the ability to perform a task that originates from learning and practice overtime (e.g., effective communication, emotional control, empathy with people, problem solving). Cyert and March (1963) stresses the programmatic and tacit nature of skills, which is often unconsciously accumulated and exercised during the activity of decision-making.

Nelson and Winter (1982), relying on Cyert and March (1963), proposed the concept of *routine* as a standardized procedure or set of activities that are executed in a specific order for achieving a predetermined objective. Routines provide structuration, consistency, and efficiency in its exercise. These two evolutionary economists proposed studying habits and tacit knowledge in the firm through the concept of routine. They considered organizational routines as the analogue of individual skills, relying on the skills of their participants. Therefore, translating the understanding of skills in individuals to the understanding of routines in organizations is valid and worthy.

In this sense, Cohen and Bacdayan (1994) argue that individuals learn the knowledge underlying the part of the routine they are responsible for in the “procedural memory.”

Gavetti et al. (2012) also proposed that if routines are maintained as distributed procedural memories, then the properties of collective routines can be understood by translating what is known about properties of procedural memory into the organization setting.

The concept of routine established the foundations for organizational studies and strategy since it is the building block of another important concept: the capabilities of organizations (Penrose, 1959). A *capability* denotes the ability of an organization to deploy tangible and intangible assets (e.g., raw assets, technology, culture, knowledge and, of course, routines) to deliver products or services to customers. Capabilities are the building blocks of strategy and their replication to other organizational settings is difficult, which makes them a potential source for competitive advantage.

In its turn, the concept of *competency* denotes the specific set of knowledge, skills, abilities, and attitudes that organizations own and leverage to accomplish their goals (Prahalad & Hamel, 1990). Since competency is a combination of the people, processes, and technologies that an organization uses in situations of organizational change, it is a kind of capability to create new sources of value to both customers and stakeholders. This may help the firm to differentiate from its competitors and create competitive advantage in its markets. The concept can also be understood as the learned and stable pattern of organizational actions by which a firm systematically creates and modifies its routines, pursuing improved competitiveness (Zollo & Winter, 2002). Although competencies rely on capabilities and routines, and can eventually modify them, they instead result from new investments in corporate projects and other actions of organizational change. This is the key difference between capabilities and competencies in the literature of strategy.

Routines, capabilities, and competencies are related concepts that have different meanings, but there are commonalities among them too. All three concepts emphasize organizational learning and knowledge creation. In evolutionary economics, routines are repetitive patterns of behavior learned and shared within an organization to perform its activities. In strategic management, capabilities and competencies refer to bundles of routines that enable organizations to deploy productive resources using routines, and adapt their routines to changing environments. If the organization is developing routines, building capabilities, or acquiring competencies, then individuals develop, acquire, and utilize knowledge and expertise over time. Another commonality is that all three concepts are context-specific, contingent on the specific resources, technologies, and social structures related to the organization. In this way, these concepts are dynamic and evolve over time under contextual changes.

Finally, Prahalad and Hamel (1990) also introduced the concept of *competence* to denote when a firm uses its resources, especially its competencies, to perform and excel in a specific domain of activity. Competence is a characteristic of the organization that demonstrates its ability to implement strategy successfully using its competencies over time, by means of value creation to customers, and eventually strategic differentiation from competitors. Competence results from sequences of projects aimed at addressing competitive problems through the creation and utilization of unique assets, information, knowledge, and competencies that are dependent on the historical context, ultimately enabling the firm to adapt to market demands, demonstrating competence development

(Foss, 1996). In its turn, competency is merely observable after the accomplishment of specific strategic goals, which results in changes in the configuration of capabilities. In summary, the concept of competency is on the category of resource stock, whereas the concept of competence is on the category of resource flow (Borrás & Edquist, 2013).

Since all these concepts involve routines and the rules of behavior that are required to implement them, this research project proposed to use two concepts from generative linguistics for modelling the cognitive dimension of organizations (Chomsky, 1965). On the one hand, *competence* is the system of grammar rules that model the linguistic knowledge of the formal practice of a natural language that all native speakers possess. On the other hand, *performance* is the empirical evidence of the real practice of a language by a native speaker, which is contingent on a specific situation. The observable linguistic output of the native speaker reveals the use of the grammar rules but under the influence of the context of language use. A configuration of initial conditions (e.g., biological, cultural or social in nature) may manifest in the form of alternative grammar rules, exhibiting a logic that diverges from the norm. The context becomes manifest on a sequence of symbols that are the outcomes of the instance of the process of using the language under investigation.

For organizations, the objective of exercising competence is to meet predetermined criteria for satisfactory performance. Nonetheless, even firms possessing a consistent and coherent set of skills, may be unprofitable (Kogut & Zander, 1996). Profitability is determined not only by the internal capabilities of a firm but also by the external factors that may affect its operations and therefore its performance. Here the Chomsky's notion of competence and performance may apply to prevent confusion with profitability.

The competence of a firm refers to a system of rules for generating sequences of decision-making events in relation to its strategy, resource endowments, legal norms, and other factors that influence firm's behavior. These rules are not formal, but rather programmatic descriptions of the firm's expected pattern of actions and interactions in pursuit of certain performance criteria.

The performance of a firm refers to an observed sequence of event outcomes taking place over time in a specific empirical setting, which may contradict expectations about the system of rules that represents competence. The unanticipated influence of either a configuration of past event outcomes or a social structure not taken into consideration (since the system is open) can result in a surprising or anomalous event outcome that requires further explanation.

For instance, Hardin (1968) and Ostrom (1990) propose distinct approaches to solve the "tragedy of the commons," which rely on empirical evidence in specific contexts, but whose effectiveness in new empirical settings cannot be anticipated due to various contextual conditions. The former approach is a single decision about privatization or nationalization of a common resource, whereas the latter is a complex pattern of actions that may enable the effective collective governance of the common resource rather than its privatization or nationalization.

This research project introduces a novel approach to analyzing firm behavior, inspired by the linguistic model, which distinguishes competence from performance. Therefore, uncovering these patterns of behavior often requires additional knowledge about the context in which this specific social process instance occurred and a systems

thinking perspective, to better comprehend the complex social processes involved in specific instances.

### 3.3 From Complex Systems to Process-oriented Theory

The concept of *system* refers to the composition of many interacting parts. However, a *complex system* exhibits emergent properties or behavior from nonlinear and dynamic interactions between its constituent parts. Predicting these emergent properties or behavior from the analysis of the properties or behavior of each individual part taken in isolation is not possible. The study of complex systems gained prominence after the publication of "General Systems Theory" by biologist Ludwig von Bertalanffy (1951), in which he identified their inherent characteristics, such as nonlinearity, sensitivity to initial conditions, and feedback loops. In this sense, Complex Adaptive System (CAS) is a type of complex system that has the ability to self-organize and learn from experience, which enable it to adapt and evolve in response to changes in its environments. Examples of CAS include biological forms of life, natural ecosystems, financial markets, social systems, and, of course, organizations.

Firms consist of various interacting components, including individuals and organizational units, which can spontaneously change strategies, structures, and processes in response to internal or external conditions. Nonetheless, Cyert and March (1963) challenged the notion that firms are conscious actors with well-defined goals, and instead proposed that firms are composed of individuals and groups with diverse preferences and interests. The authors suggested that aggregation, which involves combining individual preferences, goals, and behaviors using specific mechanisms like hierarchical authority, negotiation, or voting, is the process through which collective decisions and actions emerge. As the decision-making process is the focus of analysis, Cyert and March advocated for complex systems consisting of interdependent decision rules that respond to external feedback and internal reinforcement. Decision-making occurs incrementally, and its outcomes may depend on past event outcomes and internalized environmental conditions, rather than on rational analysis of all available information.

Since Nelson and Winter (1982) define routines as a pattern of repetitive behavior but subject to modification if conditions change, it is the routine rather than the entire organization that is more like a CAS in organizational settings. These authors also refer to routines as the economic equivalent of "genes," which are subject to variety, inheritance, and selection. Axelrod and Cohen (1999) consider that intra-organization interactions are structured, and there is no such thing as emergent macro-level behavior from micro-level processes like in CAS. In other words, organizations are not coherent emergent entities from their interacting constituent parts, but instead, their routines can coexist, sometimes influencing each other, while acting and evolving on their own in other situations.

In a seminal paper about complex systems, Warren Weaver (1948) proposed that many scientific problems are problems of complexity and advised that new research approaches and methods were necessary to solve them. In this sense, Herbert Simon (1962) argued that the complexity of economic systems could not be fully understood using the reductionist approaches of normal science. Due to their emergent properties

and unpredictability, the studying of complex systems requires very specific methods, such as computer simulations and mathematical models that can explain their structure and dynamics. Simon became an advocate for an interdisciplinary approach to complex systems research in organizational settings, relying on empirical results and techniques from economics, psychology, and sociology.

Cyert and March (1963) used case studies to create process-oriented theory based on the observation of sequences of decision-making events. This approach emphasizes the bounded rationality of decision-makers when processing and using information since they do not have access to all necessary information, and often make decisions based on incomplete information. In sequences of events of local action, decision-makers can move between distinct decision situations. In some of them, decision-making processes are highly structured and specialized, but in others, the random access of participants in the decision events results in a pattern of decision-making that is not predictable from sequences of past event outcomes themselves, which makes them stochastic processes. The second situation aligns with the neoclassical research approach, which focuses on aggregation processes and prediction of outcomes for price and quantity in markets rather than on the historical, social, and interpretive context of organizations.

Cyert and March (1963) also used a statistical methods for analyzing longitudinal data on the occurrence and timing of events of rule changes. They adapted *event history analysis*, which is a technique similar to logistic regression with the dependent variable measuring the likelihood or speed of event occurrence. The emphasis on stochastically generated sequences of events rather than on properties of emergent entities is in line with their assumptions about the nature of organizations and need for process-oriented theory. However, event history analysis was still not a complexity-oriented method.

Cohen, March and Olsen (1972) defined the research method for studying decision-making in organizations using the complexity approach as the *garbage can model*. It assumes a chaotic decision-making process with multiple problems, solutions, and participants taking place in the same decision situation, which they called *organized anarchy*. The "garbage can" randomly transforms decision inputs into an emergent outcome resulting from the interactions between problems, solutions, and decision-makers. This theoretical model rejects the rational-agent model of decision-making and accepts the nondeterminism and ambiguity of decision-making in organizations, which are realistic assumptions.

Although complex systems tend to exhibit apparently random or chaotic behavior in the overall situation, it is possible to make a qualitative assessment of their behavior. Many of the system states through which the process evolves are identifiable because they attract the trajectory to their neighborhood, such as either a strange attractor or a sink state. In fact, complex systems can be reasonable and predictable, at least in some parts, as they exhibit deterministic relationships between some types of events within specific ranges of space and time. While the complexity-oriented research approach of the behavioral view accepts the emergent nature of organizations and the unpredictability of their processes, causal relations are still deterministic, and configurational patterns of dependencies between events may be subject to inquiry using computational models (Wolfram, 2002).

This research project proposes to use grammars for empirical inquiry into complex decision-making processes. It is an algebraic, qualitative research approach to unveil complex patterns of deterministic causal relations between their event outcomes. If the structural equivalence between formal grammars and decision-making processes is a valid assumption, then process-tracing using a model of grammar rules is an effective research methodology. Chomsky (1981) argued that grammars are complex systems since they exhibit defining characteristics such as emergent properties, non-linear interactions, and sensitivity to initial conditions.

Firstly, emergence refers to the way in which new and unexpected properties or behaviors of a system arise from the complex and dynamic interactions of its constituent parts. In the case of grammar, it is the emergent and non-reducible result of a number of inter-related types or syntactic functions, such as morphemes, words, phrases, and sentences. These types interact and combine in complex ways, such that, given a valid sentence, it is not possible to explain and predict the emergent properties of its meaning and structure from the isolated meaning and structure of its component parts. In fact, in regular grammars, which are also equivalent to cellular automata, new and unexpected patterns or behaviors can arise from any small difference in the derivation of its rules over the symbols of the alphabet set. Conway's Game of Life is a good example of this phenomenon.

Secondly, nonlinearity denotes the difficulty to predict the emergent properties or behavior of a complex system (as the output) given the properties or behavior of its constituent parts considered (as the input). The use of grammar rules often encompasses non-linear interactions (i.e., combinations), such as the way in which the ordering of words and phrases takes place affect meaning or the way in which the use of distinct grammatical constructions affects the interpretation of a sentence. In fact, in context-free grammars, the existence of at least one recursive rule, which are those that may be written in the Chomsky Normal Form – i.e., $A \rightarrow B, C$, where A, B and C are non-terminal symbols –, implies in non-linearity in the derivation of some valid sentences.

Finally, sensitivity to initial conditions, also known as the "butterfly effect," denotes that small changes in the conditions at the beginning of the derivation of its rules may result in big changes in the output or final state of the system. The use of grammar rules is often sensitive to initial conditions, such that small changes in the context of the same input evidence and set of rules lead to big changes in the meaning and structure of the output sentence. In fact, in context-sensitive grammars, the existence of at least one strictly context-sensitive rule, which are those that may be written in the Penttonen Normal Form – i.e., $C, A \rightarrow C, B$, where A, B and D are non-terminal symbols –, implies in sensitivity to initial conditions, that is, to the pattern of terminal symbols that results from C.

## 4 Conclusions

The present research project does not propose another theory of the firm, but instead advocates for a meta-theory that can support comparative research on rival substantive theories using grammar models. There are no flaws in the current theories of the firm, which describe different coexisting real-world organizations. However, there is a need

for reconciliation among these theories through an integrative approach that can lead to the design of middle-range theories that are appropriate for specific empirical settings. The pursuit of the ultimate, grand theory of the firm may not be worthwhile, but the adoption of existing theoretical propositions translated into the form of grammar rules can be a promising way to explain real-world social systems.

The markets and the hierarchies are orthogonal dimensions of the space of structures for economic coordination. Markets allow for decentralization or localization of decision-making to where most of the available information and productive resources are. Conversely, firms and other forms of organization allow for centralization of decision-making to where planning of future actions and interactions takes place. In other words, while markets minimize administrative coupling between economically interdependent activities, hierarchies or hybrid forms of organization can increase them, establishing deterministic causal or dependence relationships between them, which reduces uncertainty and enables planning. Both dimensions are necessary to efficient economic coordination, but the choice of the one or the other is contingent to the contextual conditions in a specific instance of the decision-making process.

Firms and other forms of organization are not merely a "nexus of contracts" (Coase, 1937) or a "repository of resources" (Penrose, 1959); they represent a "complexity-enhancing mechanism" that can establish causal or dependence relationships between decision-making events that occurs in sequences over time. An ordered configuration of antecedent event outcomes or a future expectation about what type of event is going to occur determine the evolutionary trajectory of instances of a category of decision-making process, but this influence is often random in the markets, while planned due of administrative coupling in other forms of economic coordination.

This framework may not be able to address all the critical questions necessary for a comprehensive theory of the firm, but its objective is to establish a new research perspective on the phenomenon of economic coordination. This new perspective will enable further exploration and research aimed at achieving the ultimate goal of developing specific theories of the firm in the future.

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