Directors as Trustees: The Nash Axiomatic Approach to Multi-Stakeholder Governance

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Abstract

The view of corporate managers as agents of the shareholders has been questioned from inside and from outside the business community, with demands that they be committed, instead, to value-maximization for all stakeholders. This paper maintains that existing theories of strategy make implicit or explicit assumptions on the irrelevance of transaction costs in the processes of value creation and appropriation that result in a minor role of managers and directors in stakeholders' value-maximization. Next, it explains why managers and directors acting as trustees of the business venture, with the mission of governing and managing the business under the prescriptions of the axiomatic Nash bargaining solution, can be a transaction costs efficient way of governing the multi-stakeholders firm.

Introduction

The stakeholders' theory of strategy (Freeman, 1984, 1991) has made important progress over time, both theoretically and empirically. But it was the declarations of the US Business Roundtable (BRT), in August 2019, and of the Davos Forum, in January 2020, proclaiming its supremacy over shareholders' profit-maximization as drivers of business performance and decision making, that it reached maximum media and social attention. In recent times, two influential books, *Prosperity* by Colin Mayer (2018) and *Grow the Pie* by Alex Edmans (2020), strongly argue in favor of making purpose, not profit, the driver of business action and performance. Mayer defines business purpose as finding a way to contribute to solve the peoples' and the planet's problems profitably, while Edmans argues that business should strive to create social value, which most of the time will mean higher profits, but in some cases may not. In both cases, profit is a second order objective.

Stakeholder supremacy over shareholders, and purpose/social value supremacy over profit, raises questions about whether the dominant theories in Strategy - and in Management in general - must be revised to accommodate the proposed changes and, if so, in what direction. After all, profit and the explanation of why some firms are more profitable than others, have been core issues in those theories. The answer will very much depend on whether caring about stakeholders and maximizing social value are instrumental to profit maximization (as in the "enlightening value maximization" approach of Jensen (2002) or in the more general "enlightening capitalism" of Adam Smith (Otteson, 2019)), in which case the only change could be in the means towards an end that continues to be the same, or, on the contrary, creating social value as representing the common interest of all stakeholders, is a goal that may or may not correlate with business profitability. In the latter case, the end as well as the means must be under revision[1]. This paper examines how well equipped are existing theories of strategy such as the resource-based view (RBV), value-based competition (VBC), and the stakeholders' approach, to, individually and in an integrate form respond to the challenge of governing and managing the social value maximizing firm.

[1] For further discussion about the private versus the social returns of stakeholders' engagement in the strategic management literature see Hillman and Keim (2001), Mahoney (2013) and Henisz et al. (2014).

In the absence of conflicts of interest among collaborating parties (stakeholders) the practical question would be how to allocate resources so that the "size of the pie"-social value is maximized. However, with conflicts of interest the creation of value will have to be analyzed together with its allocation. Under ideal conditions that make transaction costs close to zero, Coase (1960) demonstrated that the conflict of interests would be solved through contracting among the interested parties around resource allocation decisions that maximize the value created. Moreover, since social value created will be generally higher than the maximum profit, the contracting mechanisms can allocate the value created in a way that shareholders earn a slice of the value created greater or equal than the forgone (maximum) profit. However, in practice, transaction costs matter and the contributions from existing theories of strategy to the challenges posed by the governance and management of the value maximizing multi-stakeholder firm will have to assessed under this premise.

This paper adopts the Nash program, in the axiomatic (Nash, 1950) and in the strategic bargaining (Nash, 1953, Rubinstein, 1982) forms for the double purpose of, understanding and articulating the relevance of transaction costs in the governance of the multi-stakeholder firm, and providing a common ground framework to integrate value-based and stakeholders' approaches to strategy[2]. The axiomatic approach is normative, and proposes solutions to bargaining problems among parties with conflicts of interest that satisfy certain principles of efficiency and fairness. The strategic bargaining approach is positive, and the agreed solution to the conflict of interests is the equilibrium solution to a multi-round process of offers and counter offers, similar to that observed in real life negotiations. The Nash program includes conditions under which the solution from the strategic bargaining process converges to the axiomatic one.

Some form of bargaining, including repeated references to the Nash bargaining solution, has been common ground in the theories of strategy. However, probably because the Nash program does not pay attention to the transaction costs of negotiation and contracting, the theories of strategy, either explicitly assume zero transaction costs, for

[2] Ross (2018: 2871) writes: "It may be time for a "strategy bargaining program" wherein the modeling community in strategy studies the micro-foundations of bargaining ability". This paper can be viewed as a step in this direction.

example with the assumption of unrestricted bargaining in VBC (Branderburger and Stuart, 1996; 2007; MacDonald and Ryall, 2004; Gans and Ryall, 2017 (for a review)), or the consideration of transaction costs is ambiguous, as in case of the stakeholders' approach (Bowman and Ambrosini, 2000; Barney, 2018; Hoskisson et al., 2019), where no formal model of bargaining has been adopted. The Nash program would predict that strategic bargaining, where the stakeholders or their representatives negotiate under certain reasonable rules, could implement the social value-maximization solution for the problem of joint production in firms, and make shareholders - and any other stakeholder - as well off in the distribution of value created as in the profit-maximizing case. But the Nash program does not acknowledge the bargaining costs incurred in the strategic bargaining process. These costs, contrary to what the theory so far has assumed, will be comparatively high; then, the governance of the stakeholders' value-maximizing firm, with stakeholders or their representatives strategically bargaining, as described in the Nash program, will likely be infeasible because of high management-like transaction costs[3].

The solution proposed in the paper is to adopt the axiomatic approach to the Nash bargaining problem as guidance for the governance and management of the stakeholders' oriented-value creating firm. For the implementation of the prescriptions from the axiomatic approach, managers and directors of the firm would no longer be agents of the shareholders; instead, they would become trustees of the collective venture. As such, their duty would be to implement the Nash bargaining solution that would come out as the result of the strategic bargaining process, but without going through the negotiation and contracting process and, therefore, saving the costs incurred in that process. Of course, the trustees' governance system would have its own transaction costs too, including the compensation of the trustees for their work and the mechanisms to make sure that they comply with the assigned duty. Then, in a comparative institutional set up, the transition towards the value-creation shareholders'

[3] Following Coase (1937) the paper will distinguish between marketing costs, i.e. the costs of using the price system for the direction of resources, and management or organization costs, i.e. the costs of using the administrative apparatus of the firm in such direction. Another distinction throughout the paper will be between what Williamson (1985) calls direct transaction costs (value of resources spent in completing the transactions, including the costs of discovering transaction opportunities, reaching agreements, writing and enforcing contracts) and transaction costs in the form of residual losses (loss in potential social value created because the direct costs of the required contracts for the implementation of the first best outcome would be too high).

firm that the reformers demand, would be conditioned on demonstrating that the trustees-like governance system can operate with sufficiently low management costs.

This paper has two complementary goals. First, highlighting the relevance of the assumptions about zero transaction costs that are explicit or implicit in the theories of strategy when applied to study value creation and appropriation in the multi-stakeholder firm. In this respect, the paper will open the black box of the coalition in VBC, will examine how the value created and appropriated is sensitive to the assumptions about unrestricted and restricted bargaining, and will question the view from VBC theory that prices are irrelevant in strategy research (Lipman and Rumelt, 2003; Gans and Ryall, 2017). The examination of the stakeholders' theory of strategy through the lens of the Nash program is new in the literature, particularly the distinction between axiomatic and strategic bargaining as ways to instrument the Nash bargaining solution that imply different transaction costs. The Nash program offers different explanations than those given in the stakeholders' theory (Coff, 1999), about the relative bargaining power of the stakeholders' groups, and refines the conditions under which price changes can provide measures of value created and appropriated, as proposed by the Value Creation and Appropriation (VCA) version of the stakeholders' theory (Garcia-Castro and Aguilera, 2014, Lieberman et al., 2017).

And second, building a bridge between the established theories of strategy and the proposals on the reform of the capitalist firm from the shareholders profit-maximizing firm to the stakeholders' value-maximizing firm. The coalition in the VBC theory creates value, not profits, and therefore is apparently better suited as a theory of the value-maximizing firm than to the theory of the profit-maximizing firm. The paper will argue that value maximization will be the criterion naturally adopted by all collective actions in the absence of transaction costs, because with the appropriate side payments the value created can be efficiently shared in a way that no party is worse-off than in the profit-maximizing solution, for example. With respect to the proposals of business reform, much is yet to be done on how the multi-stakeholder firm will be governed. The Nash program provides important insights into how to compare different governance mechanisms of the stakeholders' firm, the representation, and the trustees (Hansmann and Kraakman, 2001), within a unified conceptual framework. From these insights, the paper suggests the adoption of the axiomatic approach to the Nash

bargaining solution as guidance for the trustees' model of governance for the value-maximizing stakeholders' firm, because it can save in transaction costs compared with the costs of the representation solution.

The rest of the exposition is organized as follows. Section 1 presents an overview of the broad literature that is part of the background: theories of strategy, institutional economics, and Nash bargaining. Section 2 presents the model that reflects the decision-making process of the trustees' system of governance for the value-creating stakeholders' firm. Section 3 discusses implementation issues, and the conclusion summarizes the main results.

1. Literature review and background

Resource Based View and Stakeholders theory

The early "resource-based view" (RBV) of strategy (Rumelt, 1982; Wernerfelt, 1984; Dierickx and Cool, 1989; Barney, 1991; Peteraf, 1993) explains the superior sustainable competitive advantage of firms from individual (or bundles of) resources that are valuable, rare, imperfect of imitation (isolating mechanisms, causal ambiguity), non-substitutable (cospecialized assets, asset mass efficiencies), or semi-permanently attached to them. The focus on "knowledge", and the firm as a knowledge-bearing entity, with partially tacit and generally social complex knowledge, (Kogut and Zander, 1992) incorporates learning, integration, and resource building capabilities, as main elements of the RBV.

The stakeholders' theory of strategy connects directly with the RBV, acknowledging that the unique, firm-specific, bundles of assets are contributed by dedicated stakeholders (Wang and Barney, 2006; Barney, 2018; Hoskisson et al., 2019) whose interests must be properly protected and managed. The specific/unique assets protect the wealth created by the collaboration among resource owners from the erosion of competition. However, at the same time, the specificity of the contributed resources, the ambiguity in their sources of value, and the uncertainty in the outcome, substantially increase the transaction costs of protecting the value of the assets through complete contracts, and/or by exiting the collaboration and moving the assets to other uses

(Williamson, 1985). The "unprotected" resource owners end up with stakes in the venture, i.e., they become "true" stakeholders (Barney, 2018; Hoskisson et al., 2019; Bridoux and Stoelhorst, 2016, 2020)).

The impossibility of protecting the value of the contributed assets by contract (because the uncertainty about future contingencies prevents the use of complete contracts), and by exit (because of asset specificity), creates ambiguity about how much wealth will finally be created and how it will be distributed. Bargaining among stakeholders has been viewed as the mechanism that can resolve the ambiguity around wealth creation and allocation in the stakeholders' firm (Coff, 1999; Aguilera and Garcia-Castro, 2017; Lieberman et al., 2017). However, to date, the literature has not adopted a particular formal theory of bargaining to explain how negotiation among stakeholders will take place, and to describe the properties of the bargained outcomes. There are no references to the transaction costs incurred in the process of bargaining, including the costs of reaching agreements, and writing and enforcing the contracts. The stakeholders' theory of strategy implicitly adopts the assumption of unrestricted bargaining of the value capture theory, explained below, but without an explicit connection between the two theories; for example, the connection between "bargaining power", a term commonly used in the stakeholders' theory, and the "confidence index" used in value capture.

Barney (2018) explicitly acknowledges the incompatibility between the shareholder-oriented, profit-maximizing management and governance of firms, and the resource-based theory of strategy. However, the paper does not propose a formal governance for the stakeholder-oriented firm beyond adopting the view of the firm as a nexus of contracts (Jensen and Meckling, 1976), and including the entrepreneur-manager among the stakeholders, with the mission of "assembling the contributed resources in a unique way". How conflicts of interests among the stakeholders are resolved, and what would be the criterion that the entrepreneur-manager will follow in assembling the resources, are left out of the analysis.

Klein et al. (2019) adopt the view of the firm as an institution that must govern the collaboration of different resource owners contributing with resources that are complementary (team production technology, Alchian and Demsetz (1972)), and give their owners "enfranchised power" (stakeholders). The paper pays special attention to

the "collective management of the commons" (Ostrom, 1990) as a governance mechanism of the stakeholder firm, and compares its conditions for adoption and adaptation to internal and external changes, relative to other mechanisms, such as the hierarchy and the market (Williamson, 1975, 1985). The paper adopts a comparative cost-benefit analysis to explain the choice of one governance mechanism or another, and lists the conditions set by Ostrom (1990) for the benefits of collective management of the commons, which outweigh the costs. Among these conditions, agreement on rules of appropriation and contribution, peer monitoring, and internal dispute resolution mechanisms, all involve extensive and intensive bargaining. The potential translation into high transaction costs, in general situations, will very much condition the diffusion of governance mechanisms that involve the active and regular participation of all stakeholders in mutual monitoring and in the resolution of disputes.

In a related paper, Bridoux and Stoelhorst (2020) compare different governance mechanisms for the stakeholders' firms that involve different assumptions about whether stakeholders collaborate in a context of goal congruence, or in a context of conflicts of interest. With goal congruence, governance and management systems have to solve only coordination problems, and the question of how value created is shared among parties is irrelevant. With conflicts of interest, however, the governance system must solve coordination and motivation problems. The results of the comparison very much depend on the realism of the claim that collaboration in production among resource owners, in general, takes place without conflicts of interest.

Value Based Competition

The value-based competition (VBC) theory of strategy (Brandenburger and Stuart, 1996, 2007; Stuart 2001; MacDonald and Ryall 2004) studies value creation and appropriation in competitive environments, where collaboration and exchange takes place under conditions of unrestricted bargaining and free market entry and exit, that appear to minimize the role of stakeholders and managers. In fact, it is debatable whether it makes sense to talk about stakeholders when the assumption of unrestricted bargaining implies that all conflicts of interests can be resolved by contract at no relevant costs, and/or by exiting the collaboration with no sunk investments left behind. However, studying the capture of value in competitive environments is important

because the value created by "coalitions" of parties, generally buyers and sellers, differs depending on who joins them and the quantity and quality of the resources that are contributed. The heterogeneity and singularity of the resources and capabilities of coalitions explain why some create more value than others and, within the competitive environment, the differences in value created determine the differences in value appropriated. In this respect, the RBV theory of strategy connects with the VBC theory through the concept of competitive advantage of one coalition/firm over rivals in the market, expressed by the difference in value created (equal to utility in terms of willingness to pay, minus opportunity cost) with respect to rival firms (Peteraf and Barney, 2003; Lippman and Rumelt, 2003).

The "coalition", the basic unit of analysis of VBC theory, is a concept adopted from the theory of cooperative games (von Neumann, Morgenstern, 1944). In a production or exchange coalition, individual actors pool their resources to attain superior wealth. In the (structural) representation of the game, each coalition is reduced to a function that assigns a "value" to each set of players. The coalition is like a "black box" (Serrano, 2005) since nothing that happens inside it is relevant for the outcome from the interplay among competing coalitions. This irrelevance is acceptable in the context of the game because, by assumption, coalition members reach binding agreements about the most efficient way of combining individual resource contributions, independently of what happens in the other coalitions. No reference is made to the costs of reaching and enforcing such agreements, i.e. to the transaction costs of the coalition, neither is there an assessment of how the theory would have to be revised if the assumption of unrestricted bargaining would change to being restricted.

Although not generally highlighted, VBC connects directly with the stakeholders' theory of strategy because what happens inside a coalition is driven by value creation, not by profit maximization. The prescription from the stakeholders' approach that the firm should be governed and managed for the benefit of all stakeholders, and not solely for the profit of the shareholders, can be very well assimilated into the implicit assumption in cooperative game theory, that the "value" of a coalition is the outcome from the most collectively efficient allocation of the resources contributed by the coalition members. The contrast is evident, even though generally ignored: the stakeholders' theory of strategy claims a need for governance and management

mechanisms that will induce the stakeholders to commit unique resources to maximize the value created by the coalition/firm. The VBC assumes the maximization of value created as the goal of the coalition in the allocation of the shared resources, and minimizes the governance problem, assuming unrestricted bargaining. In VBC, the possible interference of bargaining- and contracting-related costs in the final outcome is excluded; in the stakeholders' theory, bargaining is an important determinant of the outcome in value created and appropriated, but how that bargaining takes place, and the costs incurred in the process, are generally ignored.

In VBC there are no limits to competition, i.e. to the formation of coalitions, and to the entry and exit of coalition members. Technically, the markets are perfectly contestable (Baumol et al., 1982). More players joining one coalition does not decrease the value created, and the grand coalition of all players creates, at the least, as much total value as the sum of the values created by partitions of players. The equilibrium conditions of the competition process are formulated in terms of "core" solutions (the value created by the grand coalition of players is allocated in such a way that no single player can improve by exiting the grand coalition). For a solution to being in the core, no player can receive a payoff greater than his/her marginal contribution to the value of the coalition of all players. Since the core solution is generally non-unique, the VC has incorporated concepts such as the "confidence index" and the "appropriation factor" (Brandenburger and Stuart, 2007; Gans and Ryall, 2017) to choose one core allocation as a solution of the cooperative game. Other solutions to the problem of the allocation of the value created by the grand coalition include the Nash bargaining solution.

VBC theory has been progressively modified to acknowledge the "frictions" that, in real life, can modify the outcomes of the bargaining process, mentioned, but not developed, in the original paper of Branderburger and Stuart (1996). Chatain and Zemsky (2011) first modelled these frictions, assuming that the matching of buyers and sellers in a market are not all equally likely as is generally assumed under perfect competition[4]. The factors that may condition the matching, mentioned by the authors, are: the search costs incurred by buyers (sellers) to find the preferred seller (buyer); the investment in

[4] Chatain and Zemsky (2011) connect the VBC and the RBV theories when they argue, following Malone (2001), that market frictions make markets imperfectly competitive, a necessary condition for sustainable economic rents captured by the producers.

specific assets that results in connections between buyers and sellers that cannot be replicated in outside transactions (transaction costs); and the boundaries of relevant markets that, because of trade barriers or because buyers are imperfectly informed about the attributes of the products offered by the different sellers. In the formal model, the resulting frictions appear in the form of exogenously determined probabilities of matching between buyers and sellers. The frictions considered by Chatain and Zemsky affect the working of the market (marketing costs), but not the internal working of the coalitions that are finally formed (organization or management costs). In their literature review paper, Gans and Ryall (2017) define the value of a coalition of players as wealth created net of transaction costs, with no further reference to what these costs could be and how they are determined. The representation of the coalitions of the cooperative game as "black boxes" is maintained.

Asmussen et al. (2020) extend the model of Chatain and Zemsky to compare value creation and appropriation under different, endogenously determined, horizontal and vertical configurations of the market. In a market with two buyers and one seller that can serve only one buyer, the two sellers choose between: i) getting involved in costly, mutually destructive practices that will determine the probability that only one of them will survive, that the two will survive, and that none will survive; ii) joining forces to create countervailing power to bargain with the single seller. To make the choice relevant, the countervailing power of the two buyers has a fixed exogenous contracting cost. These contracting costs contrast with the assumption in the paper that the coalitions of buyers and sellers are created, and operate, under zero transaction costs. In fact, the assumption that the two buyers and the seller bargain before the mutually destructive behavior or the countervailing power materialize, would be sufficient for such inefficient practices to not happen at all. In this new scenario, mutually destructive practices and countervailing power will be outside options in the negotiation process. They will condition how the value created by the grand coalition will be shared among the two buyers and the seller, but the efficient value-maximizing solution of the grand coalition will be assured. With unrestricted bargaining, the direct contracting countervailing cost, and the cost of the mutual-destruction practices among buyers will be saved, because neither of the two will be implemented (the outside options would not be exercised).

The Asmussen et al. paper also considers the alternative that the seller vertically integrates with one buyer to better protect the value of a cost-reducing investment from expropriation by the buyer. The investment is specific and the outside value, once the assets are in place, is zero. The vertical integration works as a protective device, but there is an exogenously given transaction (management) cost of the integrating firm that enters into the decision to integrate or not. Once again, the treatment of the organization solutions is asymmetric: there is a management cost that the vertically integrated firm has to pay, but the negotiation in the exchange between the buyer and the seller and the coalitions of buyers and sellers are all free of transaction costs. Moreover, the sequence where the seller invests today in the firm-specific asset and, in the future, the buyers bargain with the seller to capture the value created by the investment, is closer to the biform games' formulation of the VBC theory (Branderburger and Stuart, 2007; Stuart, 2016). The biform games extend the analysis, separating the stage where firms set the competition ground from the stage where bargaining for the gains of collaboration take place. In general, the decisions in the first stage are made under restricted bargaining, and in the second stage under unrestricted bargaining. This is quite important for the outcome of the game.

Consider the example 2.1 "Branded Ingredient Game" in Branderburger and Stuart (2007). In a transaction situation with one supplier and two buyers, the value created is maximized if the seller transacts with buyer one, say; then in the value-based competition and appropriation solution the seller assures a minimum payoff equal to the potential value created with buyer two. The branded ingredient game adds a pre-transaction stage where the supplier upgrades the value created together with the less efficient buyer at a cost. In the transaction stage, the value maximizing solution continues being the coalition of the seller and buyer one, but the total value created is lower than without upgrading because of the upgrading cost. The seller, however, earns a higher payoff because the net value created by the coalition with buyer two, if materialized, is higher with the upgrade. This is an example of behavior that could be justified from the point of view of a profit-maximizing supplier, but it would go against the prescription of the stakeholders' approach, where the actions must be guided by maximization of total value created across stakeholders.

And, importantly in the context of this paper, the outcome of the brand upgrading game is very much conditioned by the implicit assumption of excluding the possibility of bargaining between the seller and the buyers at the pre-transaction stage, when the decision is taken about brand upgrading or not. At this point, the brand upgrading would be the preferred outside option of the seller. From the logic of the VBC approach, the payoff of the seller in the bargaining with the most efficient buyer will increase with the upgrading option, but the option never materializes, and the cost of the upgrading will be saved. In other words, the change in assumptions about the bargaining possibilities preserves the value-maximizing outcome, and leaves the seller at least as well off as if the option would have materialized, with a destruction in value created. With the possibility of bargaining before the brand upgrading, the outcomes from VBC and from the stakeholders' approach would be reconciled.

The second example is adapted from Stuart (2001). The modelled situation includes a supplier with constant marginal production costs facing several buyers, each with a different level of willingness to pay for the product. Stuart solves the VBC biform game for a general confidence index parameter between zero and one. To simplify the exposition, let us consider the case of the confidence index equal to one that would correspond to the perfectly discriminating monopolist. This monopolist must decide how much capacity to install in stage one, knowing that in stage two he/she will be able to charge each buyer a price equal to the respective willingness to pay for the product. The optimal decision by the monopolist will be choose the capacity for which the willingness to pay of the last buyer is equal to the marginal production costs. With unrestricted bargaining, this capacity decision would maximize the sum of buyers' surplus and profits, i.e. it would maximize the total value created; the monopolist will capture all the value created in the form of profits, and the buyers' surplus would be zero. The stakeholders' approach would reach the same capacity decision by maximizing the sum of buyers' surplus and profits (the value created for the two stakeholders) although the distribution could be different (the stakeholder theory does not propose a clear value-allocation mechanism).

But suppose that the assumption of unrestricted bargaining does not hold because the monopolist has to spend money to identify each buyer, collect information about the willingness to pay, and write and enforce a non-resale agreement with each buyer. Then

the value created would have to be calculated net of the transaction costs resulting from the restricted bargaining scenario. The question now is whether there is a way to create value by reducing the transaction costs of implementing the value-created maximizing solution. If the goal is to maximize the value created (to maximize the "pie" view of the stakeholders' approach (Edmans, 2020)), the solution is to set a selling price equal to marginal costs and sell the product at this price to any buyer who demands it. The demand would be the same as that of the perfectly discriminating monopolist but the trade will be anonymous, there is no bargaining at all, and transaction costs would be minimized.

With price equal to marginal cost and returns to scale in production are constant, the profits of the seller will be zero and all the value created goes to the buyers in the form of consumers' surplus. If the seller does not accept this solution and side payments are possible at no cost, the buyers may make payments of this kind to the seller for the amount of profits agreed upon. If side payments are not feasible and the seller is not satisfied with zero economic profits, there is another way to save in direct transaction costs: sell the product at a single per-unit price, the same for every buyer, but the price is not equal to the marginal cost but to the profit-maximizing one. Now the transaction cost will be in the form of residual losses (there are buyers who value the product more than the marginal cost but less than the profit-maximizing price), but, all in all, it may be the most efficient solution. With unrestricted bargaining, many outcomes are possible, which is fine to begin with; but a robustness check considering what would happen under restricted bargaining is a wise thing to do.

The institutional approach

Coase (1937) defined the firm as the set of relations that result when the entrepreneur replaces the price mechanism in the direction of resources. The definition identifies two institutional alternatives in the private sector of the economy for the coordination of the decisions of specialists in the allocation of resources: the market (price system) and the firm (the administrative decisions of the entrepreneur). In a later article, Coase (1960) examined a problem previous to that of the direction of resources: the allocation of ownership and decision rights over the productive assets in the economy when there are external effects in the exercise of these rights. Now the firm emerges as an entity that

concentrates the ownership of all the assets whose individual economic value depends on the decisions about the use of any of the other assets (strong external effects across assets' values).

The example of the use and ownership of community land, for farming or herding, illustrates the problem of external effects and the joint ownership solution. Two individuals, a farmer and a herder, have decision rights to the use of the land, and as the number of herds increases, the value of the land dedicated to herding increases and the value of the land for farming decreases. The farmer and the herder may bargain and contract the most efficient (total value maximizing) way of sharing the land, to include both farming and herding activities, and agree on the resulting payoffs for each party. Or, alternatively, there could be a single owner of the land who will decide on its best use, acknowledging the mutual technical or productive interrelations between the two activities; single ownership would make bargaining and contracting unnecessary. The concentration of ownership of the complementary assets in a single firm will allow the owner of the firm to use administrative mechanisms, instead of the rearrangement of rights by contract, in the decision on how the assets would be used in the joint production[5].

The problem of joint production with complementary assets is also at the core of the theory of the firm of Alchian and Demsetz (1972) that has influenced the "team production" approach to the governance of the stakeholders' firm (Ostrom, 1990; Blair and Stout, 1999; Mahoney et al., 2009; Klein et al., 2012, Klein et al, 2019). The team production technology refers to production situations where the output produced with several inputs used together is higher than the sum of the outputs produced if each input is used separately. In other words, there exists complementarity among resources so that the marginal productivity of each of them increases with the input quantities of the others. Complementarity among assets creates externalities in the contribution of one asset to the output from the quantities of the other assets that the market system cannot deal with. However, for these externalities to be relevant, a second condition is necessary, in addition to team production technology: that the complementary assets

[5] Coase (1960) does not mention the relevance that the single owner is a physical person, an entrepreneur, or a legal entity (a corporation).

belong to different owners. As in Coase, single ownership will assure that the owner will internalize the externalities so as to maximize value.

The distinction between human and non-human assets turns out to be particularly relevant in answering the question of how to allocate ownership rights across complementary assets in production. The embedded human capital is non-transferable, while the ownership of the non-human capital is, in general, transferable without major restrictions. The concentration of ownership of assets in a single firm could then apply only to the non-human capital. But, even in this case, concentration may not be the most efficient solution. When non-human assets are complementary to the human capital of the workers, the value of human capital in outside options from the current joint production will increase with the non-human capital assets that the human capital is combined with, in the respective outside option. In a dynamic context, where individuals decide how much to invest in human capital specific to the firm, and where information asymmetries restrict the contracting situation of the employees with the firm to incomplete contracts, the human capital investment decision at time zero will be conditioned on the value of the human capital in outside options in time t in the future. If the ownership of non-human capital is concentrated in a single firm, the outside value of the human capital will be low and, anticipating this situation, there will be no incentive to invest in specific human capital to begin with[6]. Then, it cannot be excluded that, in the dynamic context just described, it may be more efficient, in second-best terms, to distribute the ownership of non-human capital in different firms, or across different owners, that are controlled by those who invest in the complementary human capital (Grossman and Hart, 1986; Hart, 1995).

The relevant scenario for the governance of the stakeholders' firm will then be that of joint production under the complementarity conditions of the team production technology, with contributions from owners of human and non-human capital, distributed in separate persons, physical or legal. We conjecture that the growing importance of knowledge-based assets, and intangible assets in general, in the modern economy, probably increase the value of specific human capital, and therefore it is important to provide the right incentives to invest in this capital (Bae et al., 2011;

[6] Bosse et. al. (2020) study how mergers and acquisitions, with changes in the ownership of non-human assets, can destroy valuable firm-specific human capital.

Edmans, 2012). Addressing the governance problem in these situations will involve decisions on organization-firm boundaries, and mechanisms to resolve conflicts of interest within the organization boundaries. In the latter case, the "owners" of the firm must necessarily be "weak" and managers must be strong, in the sense of assembling true resource owners with stakes in the joint production. The situation will resemble more the governance of alliances and joint ventures than the governance of the corporation that owns most of the non-human assets used in production.

The arrangements of ownership rights by contract in the market environment, or by administrative decisions within the firm, when dealing with external effects (in the decisions over some assets or activities) on the value of the others, are not the only ones. There are also the possibilities of the collective governance of the commons (Ostrom, 1990), and direct government regulation (Coase, 1960). The restrictive conditions under which the collective governance works, with mutual monitoring and group-sanctioning mechanisms, was mentioned above. Government regulation, stating by law what individuals can or must or cannot do, and having at its disposal coercive mechanisms, such as the police or the courts to enforce compliance, can be advantageous in cases where bringing many diverse activities and assets into the firm that affect many individuals with whom interaction is complex. This would be the case, for example, with externalities from environmental damage, the depletion of natural resources and other related activities, with stakeholders that have difficulty organizing themselves to defend their interests. For the purpose-driven corporation, as described by Mayer (2020), the direct intervention of the government could be justified when solving individual – and planetary - problems by the firms is not a profitable activity, because it would result in too high transaction costs, for example. The government can contribute to production with external subsidies or with the direct provision of goods and services, in the cases absorbing the financial deficit. Then, specialization between firms (administrative decision making, concentration of private property of complementary assets) and direct government intervention (the coercive power of the State) where caring about externalities are the responsibility of one or the other mechanisms, would be determined by comparative transaction costs too.

This paper will leave out of the analysis the interplay of firms and governments in delimiting the respective responsibilities in internalizing the external effects that

transcend the possibilities of individual firms, such as those that inevitably lead to climate change, or the supply of basic goods for everyone. The stakeholders' groups considered in this paper will be those that can organize themselves and act as groups in the protection of their respective interests. The governance system of the firm will have to give voice to, and may also be subject to a vote by, all the stakeholders' groups, something that has already been contemplated in the literature. In this respect, Hansmann and Kraakman (2001) differentiate between the dominant model of corporate governance of the shareholders' firm, with managers and directors acting as "agents" of the shareholders, and the models of "representation" and of "trustees" proposed for the stakeholders' firm. In the shareholders firm, the problem is how to provide the agents of the shareholders with the right incentives to serve the interests of the latter (the principal). Since the shareholders care for the economic value of the assets invested and that contributed to finance, the duty of the agents, managers and directors, is to maximize the economic value of the assets. The governance problem is complicated by information asymmetries between passive investors and the management team that can result in short-termism that penalizes the shareholders too. In any case, the governance problem of the shareholders' firm with managers as agents of the shareholders, differs from the problem of internalizing externalities that motivated the theory of the firm of Coase (1937) and of Alchian and Demsetz (1972).

In the representative governance of the stakeholders' firm, qualified non-shareholder constituencies appoint their own directors, who jointly bargain with the board of directors to craft policies that, presumably, will maximize the joint welfare of all stakeholders, and allocate the gains according to some given criterion, for example, the respective bargaining power. In the trustee model, the board of directors and the senior managers act on behalf of the entire enterprise by coordinating the contributions and returns of all of its stakeholders, without these stakeholders or their representatives going through an explicit bargaining process. In both situations, the governance problem is how to internalize the externalities of decisions on one asset, in the economic value of the others. In the representative model, the internalization takes place through the bargaining process and the resulting contract, explicit or implicit, determines how much, and under what terms, each resource owner-stakeholder will contribute to the joint production. In the trustee model, the boards and directors must present solutions that replicate those that would be bargained over.

In any case, the theory and practice of the shareholders-agency approach to corporate governance, complemented with the market for corporate control (free entry and exit of shareholders) are much more extensive than the stakeholders' model. The closest empirical reference of the representative model would be the corporate governance system of co-determination in central and northern Europe, where employees elect representatives to corporate boards, with decision power similar to that of the representatives of the shareholders (Fauver and Fuerst, 2006; Lin et al., 2018). However, the representation of employees is set by law, not by the voluntary decision of the shareholders concerned about the incentives of employees to invest in specific human capital (it could be argued that the representation of employees as a legal obligation may help to solve the coordination problem, and that shareholders are happy with employee representatives on boards). Aoki (1986) views the managers and directors of Japanese firms as mediators between capitalist and workers that made it unnecessary that employees named representatives to boards, but with similar final outcomes, and Mayer (2018) argues in favor of directors as trustees for the purpose-driven corporation[7].

The Nash bargaining program

The Nash Bargaining program is a body of knowledge to overcome conflicts of interest that belongs to the family of Cooperative Games (CG). In CG, the basic ingredient of the collective action is an indivisible agreement among collaborating parties that emerges after the social actors have exhausted all available production or exchange possibilities, and reached a Pareto-efficient outcome. The indivisible agreement is "binding" for the participating actors so that, once the agreement is reached, the decision power is the invisible public property of the group as a whole, named a *coalition*. In CG, conflicts do exist but can be overcome with contracts that allow the members of the coalition to extract the best from the available resources. When the contracts and binding agreements are not feasible, the Game must adopt a representation

[7] Several papers have examined the governance role of representation of employees in business decisions, sometimes protecting the interests of shareholders from potential appropriation practices of managers (Huang et al., 2017), and others forming alliances with the management team to extract rents from the shareholders (Pagano and Volpin, 2005).

different from the coalition, in which the decision power is distributed among the players (each one controlling his/her own strategic choices), and where the final outcome will be the result of each player choosing their own strategy. The game changes from "cooperative" (with contracts and binding agreements) to "non-cooperative" (decentralized strategic behavior). Nash (1951) is a seminal contribution to the theory of Non-Cooperative Games (NCG), arising from the Nash equilibrium concept.

Within a coalition, there can be many Pareto-efficient outcomes and it will be important for the players who eventually join the coalition to know which will be the chosen one. If participation in the coalition is voluntary, the feasible Pareto-efficient solutions to the game can be restricted to those that satisfy the condition of *individual rationality*: a Pareto-efficient payoff, for which each coalition member receives at least the payoff in the best outside option. But collective and individual rationality conditions may still not reduce the efficient solutions to a single one. Nash (1950) first proposed a normative/axiomatic solution for a cooperative game where two players, bargaining for a choice among the payoffs that satisfies the collective and individual rationality conditions. The *axioms* are restrictions that the final solution of the two-person cooperative game must satisfy:

Symmetry: If there is no information that lets us distinguish between the players in a bargaining game's description, then that game's solution should also not distinguish between the players.

Pareto optimality: The idea of this axiom is that, once the bargaining solution is set, the players should not be able to improve upon the solution outcome without making the other player worse off.

Individual rationality. All players should accept the bargaining solution, which implies that each player receives a payoff at least equal to the payoff in the case of no agreement, and the collaboration does not take place.

Invariance to equivalent payoff representations: The bargained solution should be the same for any measure of the payoffs that is a linear transformation of the others. This is immediately true for payoffs expressed in von Neumann-Morgenstern utility terms.

Independence of irrelevant alternatives: This says that letting the feasible set of bargained solutions shrink while the solution outcome remains feasible, then the bargained solution should not change.

The elements of the two-person Nash bargaining problem are the vector of feasible payoffs $S = (S_1, S_2)$, with $S \subset P$ (the feasible set); the best outside option that will determine the payoffs if the bargaining process fails, (s_1, s_2); and the Neumann-Morgenstern utility function defined over the payoffs, $U_i(S_i), i = 1, 2$. Nash (1950) showed that the solution of the bargaining game that satisfies the axioms (axiomatic solution) can be calculated through the optimization problem:

$$Max_{S \subset P}(U_1(S_1) - U_1(s_1))(U_2(S_2) - U_2(s_2)) \qquad \text{(P1)}$$
$$subject\ to\ U_i(S_i) \geq U_i(s_i), i = 1,2$$

Harsanyi and Selten (1972) extended the Nash bargaining solution to situations where negotiating parties have different bargaining power (contrary to the symmetry axiom). They propose the *weighted Nash solution,* defined by maximizing the product of utility gains raised to "powers" that differ across agents and altogether add up to one. Harsanyi (1977) generalized the Nash bargaining solution to the N-person cooperative game, with N≥ 2.

The optimization problem that solves for the Nash axiomatic solution cannot be taken as representative of the rational behavior of an economic actor (maximization of utility or maximization of profits), and for this reason it is unclear how it will be implemented. The *Nash program* initiated by Nash (1953) is an intent to complement the axiomatic approach with an analysis of the bargaining problem in which the strategic moves of offers and counter-offers of the players mimic the bargaining procedures observed in real face-to-face negotiations. The strategic moves of the players change the nature of the game from cooperative to non-cooperative, since now the decision power is decentralized among the players, but the assumption of binding agreements is maintained. If the equilibrium outcome of the non-cooperative formulation of the bargaining game coincides with the axiomatically determined solution, the implementation problem would be solved.

Rubinstein (1982) advanced the formulation of the non-cooperative bargaining game, including recognizable bargaining procedures with offers and counter-offers by the players, till an equilibrium outcome is reached that coincides with the Nash axiomatic solution. Strategic bargaining was viewed as the mechanism to implement the Nash axiomatic solution. Binmore (1987), Binmore et al. (1986), and Sutton (1986), among others, contributed to the program with refinements in the definition of the outside or disagreement payoffs, and with the determinants of the power parameters of the weighted Nash solution (see Serrano (2005) for a review). Collar-Wexler et al. (2019) and Serrano (2020) provide updated reviews of the literature on the theory and applications of bargaining in production and exchange, and generalize the solution to the implementation problem in exchanges participating in multiple upstream and downstream firms.

The axiomatic and the strategic bargaining solutions to the Nash bargaining problem have not been seen as competing solutions to the same problem. Rather, the strategic bargaining approach has been viewed as a way to add realism to the axiomatic solution, for which the implementation problem appears insurmountable. However, the strategic bargaining solution ignores the transaction costs of implementing the bargaining process, including the writing and enforcing of the agreement reached at the end of it. When the bargaining-transaction costs matter, which will be the rule, not the exception, the axiomatic solution appears as a cost-effective alternative: choose and implement a solution to the bargaining problem that is close or identical to the solution that would have emerged from a costly bargaining process, but saving the inevitable transaction costs of that process. This paper proposes that the axiomatic-strategic bargaining solutions to the Nash bargaining problem can be adopted as theoretical benchmarks in thinking about the governance problem of the stakeholders'/value creation and capture approaches to Strategy, with strategic bargaining as a counterpart of the "representation" governance, and the axiomatic one as a counterpart of the "trustees" governance.

2. The trustee's implementation of the Nash axiomatic solution in the governance of the stakeholders' firm

This section outlines the Nash bargaining solution to the allocation of resources and the allocation of value created in the stakeholders' firm, as it would be when implemented following the trustee's model. It can also be viewed as the VC approach to the problem of managing the allocation of resources within a coalition.

We define $x_i, i = 1 \dots N$, as the quantity of non-capital variable input i; $v_i(x_i), i = 1 \dots N$ as the outside value of the quantity of resource input i, i.e. the value in alternative uses of the input in case of disagreement; $q = F(\hat{q}; x_1, x_2, \dots x_N) = F(\hat{q}; \vec{x}), q \leq \hat{q}$, as the production function of the firm, i.e. the maximum output that can be produced with the quantities of variable inputs and installed capacity q; $C(q) = Min \sum_i v_i(x_i), subject\ to\ q = F(\hat{q}; \vec{x}), q \leq \hat{q}$, as the variable cost function for the quantity of output produced q. In addition to the resource owners of non-capital inputs, other collaborating parties are the buyers, identified by sub-index "B", the financial investors who finance the capacity $\hat{q}$ (one unit of capacity costs *k*); and a competitor who offers to the buyers the possibility of getting a substitute product with value for the buyer equal to W_c. The buyers earn a total utility equal to $U(q)$from the consumption of the quantity produced q, expressed in money equivalent (willingness to pay), and this utility will be shared by the non-capital input owners, $S_1, S_2, \dots, S_N$; the investor that finances the productive capacity, S_I, and the buyers in the form of consumers' surplus, S_B.

The optimization problem, a generalization of (P1) above, that would solve the Nash bargaining solution that satisfies the list of axioms (except for permitting different bargaining power among the resource owners) would be formulated as follows:

$$Max_{q, x_1, x_2, \dots, x_N; S_1, \dots, S_N} (S_B - W_c)^{\alpha_B} (S_I - k\hat{q})^{\alpha_I} \prod_i \left(S_i - v_i(x_i)\right)^{\alpha_i}$$

$$\sum_i S_i + S_I + S_B = U(q)$$

$$q = F(\hat{q}; x_1, x_2, \dots x_N)$$

$$q \leq \hat{q}$$

Where the weights of bargaining power $\alpha_B, \alpha_I, \alpha_i, i = 1 \dots N$ are non-negative and sum to one. This problem summarizes the objective function and constraints that would guide the direction of resources of the managers as trustees, equivalent to the problem

of profit maximization that represents the objective functions and constraints of the shareholders, and of the managers as the agents of the shareholders. The difference is that the profit-maximization problem can be justified from a positive point of view because the profit is the rent of the maximizing shareholders or their agents. The problem above can only be justified from normative terms, i.e. following the prescriptions implicit in the list of axioms. The first order conditions for the optimal solution provide more intuition on how to make decisions about resource allocation and the distribution of value created:

$$q = \hat{q} \tag{1}$$

$$x_i(\hat{q}): \quad \frac{\Delta \mathrm{U}}{\Delta \mathrm{q}} \frac{\Delta \mathrm{q}}{\Delta x_i} = \frac{\Delta v_i}{\Delta x_i}, i = 1 \dots N \tag{2}$$

$$S_i(\hat{q}) = v_i\big(x_i(\hat{q})\big) + \alpha_i(U(\hat{q}) - C(\hat{q}) - k\hat{q} - W_c) i = 1 \dots N. \tag{3}$$

$$S_B(\hat{q}) = W_c + \alpha_B(U(\hat{q}) - C(\hat{q}) - k\hat{q} - W_c) \tag{4}$$

$$S_I(\hat{q}) = k\hat{q} + \alpha_I(U(\hat{q}) - C(\hat{q}) - k\hat{q} - W_c) \tag{5}$$

Equation (1) says that in the Nash axiomatic solution the output produced will be equal to installed production capacity. Equation (2) indicates that in the Nash solution the quantity of variable resource inputs used in production is that for which the marginal contribution of the input to the value of the output is equal to the marginal opportunity cost of the input. Equations (3), (4) and (5) correspond to the allocation of the gross value created, $U(\hat{q})$ among resource owners and buyers. In all cases, the payoff is equal to the outside value of the input and the consumption opportunity (in the case of buyers), plus a share of the net value created, proportional to the respective bargaining power.

The capacity investment decision

The manager-trustee solves the problem above at time t, but previously, at time 0, financial investors decide on the production capacity, $\hat{q}$. The payoff of the investors at time t is $S_I(\hat{q})$ given by equation (5). At the time of the investment, time 0, the investors

will choose the capacity that maximizes their profit, equal to the payoff minus the cost of the investment: $\Pi_I = S_I(\hat{q}) - k\hat{q} = \alpha_I(U(\hat{q}) - C(\hat{q}) - k\hat{q} - W_c)$. For positive α_I the investors will choose the capacity that maximizes profits. The first order conditions of optimal:

$$q^*: \frac{\Delta U}{\Delta q} = k + \frac{\Delta C}{\Delta q} \qquad (6)$$

The profit-maximizing capacity is also the one that maximizes the value created, i.e., that capacity for which marginal utility is equal to marginal cost that includes the marginal cost of the rest of the inputs used in production, C'_q, plus the per unit capacity cost *k*.

In this calculation, the investment in capacity is a general asset that at time t has an outside value of kq^*that, in turn, is the opportunity cost of the capacity when used in the joint production. What would happen if the asset was specific to the collaboration? If the asset is totally specific, its economic value outside the transaction is zero; at time t, when the investment is already made, the cost is sunk and the opportunity cost of being used in the current production is zero. With $k\hat{q} = 0$, the payoff at time t for the investors would be $S_I(\hat{q}; I\ specific) = \alpha_I(U(\hat{q}) - C(\hat{q}) - W_c)$ and the profit at time zero, $\Pi_I(I\ specific) = S_I(\hat{q}; I\ specific) - k\hat{q} = \alpha_I(U(\hat{q}) - C(\hat{q}) - W_c) - k\hat{q}$. If the investors choose the capacity that maximizes profit at the time of the investment, time 0, the capacity installed will be that which satisfies the conditions:

$$\breve{q}: \frac{\Delta U}{\Delta q} = \frac{k}{\alpha_I} + \frac{\Delta C}{\Delta q} \qquad (7)$$

The two capacity decisions will coincide, $q^* = \breve{q}$ only if $\alpha_I = 1$, i.e. the investor has all the bargaining power. When $\alpha_I \leq 1$, the investment in capacity from (7) will be less than or equal to the capacity that maximizes the value created. When the asset is of general use, the possibility of exiting the joint production situation and having alternative uses of the market for the asset that pay at least the investment cost, is sufficient to protect the value of the investment and proceed with the optimal investment decision, even if bargaining power is very low. If the asset is specific, the exit decision when the investment has already been made is not effective in protecting

the value of the asset; then, one way to induce optimal investment is to give the bargaining power to the investors who finance the asset.

If the production capacity, a tangible non-human capital asset, is the only specific asset, the shareholders' ownership and governance solution can work, particularly when markets are competitive: the investors create a legal entity, fund it with cash, and the legal entity uses the cash to finance the investment in the tangible capital. The other production inputs are purchased in the market at market prices and, if the output market is competitive too, the output is sold at the market price. As long as assets are non-human and ownership transferable, the shareholders' firm could own all the complementary assets specific to the joint production and protect the value of the assets through ownership. More complicated is the case where specificity affects the assets whose ownership is non-transferable, human capital in particular, as discussed in the background section. How the trustees' governance system can respond to this situation will be discussed in more detail in the implementation section.

The distribution of value created

For simplicity of exposition, assume that the capacity investment decision is q^*. Replacing this capacity value in the equations above will determine the final value created and its allocation across buyers and resource owners; Table 2.

Table 2. Gross and net wealth from the Nash bargaining solution

	Gross payoff: Utility and income	Net payoff: wealth allocated: Utility and income net of buyers' payment and opportunity costs of resources
Buyers	$U(q^*)$	$U(q^*) - R(q^*) =$ $\omega_B^* = W_c + \alpha_B(U(q^*) - C(q^*) - kq^* - W_c)$
All resource owners (firm)	$R(q^*) = (1-\alpha_B)(U(q^*) - W_c) + \alpha_B(C(q^*) + kq^*)$	$\Pi^* = R(q^*) - C(q^*) - kq^* =$ $(1-\alpha_B)(U(q^*) - C(q^*) - kq^* - W_c)$
Variable inputs owners	$S_i^* = w_i^c x_i^* + \alpha_i(U(q^*) - C(q^*) - kq^* - W_c)\ i = 1, \dots N$	$\omega_i^* = S_i^* - w_i^c x_i^* = \alpha_i(U(q^*) - C(q^*) - kq^* - W_c), i = 1, \dots N$
Investors in capacity	$S_I^* = kq^* + \alpha_I(U(q^*) - C(q^*) - kq^* - W_c)$	$\omega_I^* = S_I^* - kq^* = \alpha_I(U(q^*) - C(q^*) - kq^* - W_c)$

The term $R(q^*) = (1 - \alpha_B)(U(q^*) - W_c) + \alpha_B(C(q^*) + kq^*)$ is the side payment that buyers make to the firm-trustee, as counterpart to receiving and consuming the output produced. The buyers consume the output and get a utility from such consumption (first column); the buyers' surplus, utility minus payment, is ω_B^*. The gross payoff of the firm is the revenue from the buyers, and the net payoff is equal to the economic profit (revenue minus opportunity cost of the resource inputs (second column). Each resource owner receives the gross payoff determined by the Nash bargaining solution, first column. The wealth created appropriated by each resource owner different from productive capital is, $\omega_i^*, i = 1 \dots N$.

Adding the wealth appropriated by buyers and resource owners from the second column of Table 2, the result is $W^*(q^*) = U(q^*) - (C(q^*) + kq^*)$, i.e. the wealth created from production and consumption of the new product, equal to the difference between the utility of buyers from consumption and the opportunity costs (outside values) of the fixed and variable inputs used in the production, all evaluated at the value-maximizing capacity of production. Since there are other products for the buyers to satisfy their needs, the *added value* of the new product is $W^*(q^*) - W_c$, i.e., the difference between the wealth created from the production and consumption of the new product, and the wealth created from the consumption of the substitutes. For non-negative wealth appropriated by the resource owners, and therefore for the viability of the coalition, Table 2 indicates that it is necessary and sufficient that the incremental wealth be non-negative $W^*(q^*) - W_c \geq 0$, i.e., the firm creates at least the same value as the best alternative to satisfy buyers' needs. When this condition is satisfied, the buyers are not worse off consuming the new product than the substitute, and all resource owners earn a non-negative quasi rent from participating in the collaboration.

The Nash solution assures Pareto efficiency (social welfare maximization) and stability (the wealth allocation is in the core only when the grand coalition and the coalitions of individual partners are considered). If $W^*(q^*) - W_c < 0$ i.e., the wealth created in the new venture is less than the wealth created by other possibilities of satisfying buyers' needs in the market, the coalition will not form, which is preferred from a social welfare point of view because, if it did, it would destroy wealth. From Table 2, the economic

profit of the firm, column 2, is proportional to the added value, $\Pi^* = (1 - \alpha_B)(W^*(q^*) - W_c)$. For a given bargaining power, added value and profits are jointly determined. In this case, it would make no difference to assess the competitive advantage in terms of differences in value created, or in terms of differences in profits[8].

The collection of revenues from buyers and the payment to the resource owners

The allocation of value created in Table 2 requires direct side payments among the parties involved in joint production, such as those shown in (3), (4) and (5) above. The role of a manager could then be to collect the revenues from the buyers/consumers, and the execution of the corresponding payments to the resource owners. One possible way to instrument the side payment is by setting a price per unit of quantity. From the total side payments that buyers make to the manager in Table 2, the average unit price that buyer would pay is,

$$\bar{\bar{p}} = \frac{R(q^*)}{q^*} = \frac{(1 - \alpha_B)(U(q^*) - W_c) + \alpha_B(C(q^*) + kq^*)}{q^*} \qquad (8)$$

In the conventional approach of no side payments, the manager could announce this average price and let the buyer respond with the quantity demanded. However, this solution may not work, because at this average price the buyers would demand the quantity $\bar{\bar{q}}: U'_q = \bar{\bar{p}}$; in general, this quantity will not coincide with $q^*: U'_{q^*} = C'_{q^*} + k$ because the price will differ from the marginal production and investment cost, $\bar{\bar{p}} \neq C'_{q^*} + k$.

For the linear price mechanism to work properly, it would be necessary that a price equal to marginal cost would generate payments from the buyers to the seller close to the total side payments from the Nash solution. This could happen in some special cases. For example, the cost of producing q, $C(q)$, is an increasing, $C'_q > 0$, and convex

[8] Lieberman (2020) criticizes the use of the term "competitive advantage" of firms in strategy because there is no unified definition of the term (in some cases, it is defined as higher value created and in others as superior financial performance), and because, for a given definition, the term is only well-defined when the higher value created is constant for all units of output. In the result presented here, profits and added value are defined for the aggregate of all units produced; the added value of the firm with respect to the competitor can differ across units of output but, in the aggregate, there is a proportionality between added value and profitability. The results suggest that the link between added value (ex-ante proxy competitive advantage) and financial performance (ex post proxy) will be context-dependent.

function $C_q'' > 0$, in q. The pricing policy of unit price equal to marginal cost, $\bar{\bar{p}} = C'_{q^*} + k$ will result in the first best production and consumption quantity, q^*: $U'_{q^*} = C'_{q^*} + k$ and generate a total revenue greater than the production cost $R_1(q^*) = C^*_{q^*} q^* + kq^* > C(q^*) + kq^*$and, eventually, close to the amount of side payments implicit in the bargained solution[9].

When the rule of price equal to marginal cost does not generate the revenues from the buyers that correspond to the payment that they must make from the Nash bargain solution, some form of side payment will have to be implemented. A two-part tariff pricing, where the buyer pays a fixed amount for the right to buy the product, and a unit price equal to marginal cost, could work:

$$R(q) = f + (C'_q + k)q \; if \; q > 0 \; and = 0 \; if \; q = 0$$

The two-part tariff is equivalent to paying an average unit price decreasing with the quantity consumed, $\frac{R(q)}{q} = \frac{f}{q} + C'_q + k$, where the price paid for the last unit of the product is always equal to the marginal cost. The fixed part of the tariff would be adjusted so that the buyers make the side payment determined by the Nash solution. The two-part tariff could work if buyers consume more than one unit of the product, and the fixed part of the tariff is a payment that can be detracted from the utility of consuming the intra-marginal units of the product. Another condition is that the buyers cannot resell the purchased quantity of output.

In the payment to the resource owners, the problem is similar: how to assure that the resource owners receive the payoff determined by the Nash solution, and at the same time the marginal conditions for optimal resource allocations are satisfied? To be more specific, consider the case where the opportunity cost of each variable resource input for production is determined by a market price times a quantity purchased, as follows,

[9] When the marginal cost is decreasing $C_q'' < 0$, the revenues collected with a pricing policy of price equal to marginal cost will generate total revenues lower than the total production costs, and therefore to collect what the buyers have to pay, some form of side payment mechanism would be necessary.

$v(x_i) = w_i^c x_i, \forall i$. Then, the average payment per unit of resource input in the implementation of the solution would be, including the investors,

$$w_i^r = \frac{S_i(q^*)}{q^*} = w_i^c + \frac{\alpha_i(W^*(q^*) - W_c)}{q^*} \qquad (9)$$

$$k^r = k + \frac{\alpha_I(W^*(q^*) - W_c)}{q^*} \qquad (10)$$

The marginal cost of the variable resource input is now the market unit price, $w_i^c \ \forall i$ and k. With the market price, the manager can determine the optimal, wealth-maximizing, quantities of resource inputs in production, but paying the input owners the market price will not implement the payoff determined by the Nash solution. In order to not distort the optimal production decision and, at the same time, allocate the wealth created as prescribed by the Nash solution, some side payments will be necessary.

The exposition above points to the different role of prices: providing information that is relevant for decision making (for example, on demand and capacity decisions), and as instruments in the implementation of the side payments resulting from the bargained solution. In situations where the side payments are not feasible, the prices must play the double role of providing decision-making information and allocating the wealth created, at the same time, which restricts the possibilities of wealth creation. With side payments, the two functions of the prices can be detached, and, in fact, there could be a different price for one function (for example prices that inform about unit opportunity costs in decision making), and for the other, prices as average payments per unit of ex post input or output[10].

The difference between prices that affect the ex-ante production and consumption decisions, and prices that instrument the side payments and distribute the wealth created ex post, can have practical implications in the measurement of wealth created, because, in general, it will be difficult to know if the observed price corresponds to one or the other. The difficulty in measuring wealth created and appropriated with published data

[10] The value capture theory specifically argues that "specifying prices, quantities and costs is not the goal of this sort of analysis" (Gans and Ryall, 2017: 20); see also Lippman and Rumelt (2003). We claim that not having to specify prices and quantities is a consequence of assuming binding agreements at no transaction costs and, ultimately, of the view of the coalition as a black box.

by firms (accounting statements and management reports) is well understood. Among other things, because consumers' surplus and the opportunity cost of equity are not available. There have been several attempts to overcome these limitations; one of those, closely related to this paper, is the Value Creation and Appropriation (VCA) approach to the stakeholders' theory of strategy (Garcia-Castro and Aguilera, 2014, Lieberman et al., 2017).

The VCA approach assumes that willingness to pay and opportunity costs are relatively stable between two periods of time, and from this assumption the claim is that changes in wealth created and appropriated will be mainly driven by changes in prices and costs (Garcia-Castro and Aguilera, 2014; footnote 3). It is clear from this statement that price is detached from willingness to pay, and that cost is detached from opportunity cost; in other words, the VCA approach assumes that the observed prices used in the calculations of wealth created and appropriated (in reality, their changes during a limited period of time) are different from opportunity costs (for buyers and sellers), and that the opportunity costs and value do not change over time. But no detailed explanation is given about what determines the observed prices[11]. Appendix II shows the application of the VCA approach for prices calculated from the Nash bargaining solution (equations (8) to (10)).

3. Implementation issues

Stakeholders

The implementation of the trustees' model of governance, with the duty of maximizing value created for all stakeholders, will require the identification of the stakeholders' groups. From the exposition above, the parties with "true" stakes in the joint production will be those that financed the investment in specific assets, and the parties that have no alternative to avoid negative externalities (for example, moving to a different place to avoid air pollution). Asset specificity turns the investment in these assets into a sunk cost, i.e., the economic value of the asset in uses other than those to which it was initially dedicated, tends to zero. When the asset is general, it will be easy to find

[11] In Lieberman et al. (2018) the assumptions are modified so that prices in the initial period are equal to opportunity costs, and profits of firms are equal to zero (selling price equal to marginal cost).

alternative uses with sufficient return to recover, at least, the initial investment cost; the resource owners can protect the value of the asset and avoid delay in exercising their exit option. There is a claim from the stakeholders' theory of strategy that specificity is a necessary condition for an asset having strategic value (to create a competitive advantage), but for the value-capture theory, the competitive advantage comes from superior wealth creation, and this can be achieved with a better assembly of complementary assets, specific or not (Barney, 2018).

The case of decisions that destroy the natural environment or damage the local community is more complicated. Those affected by these externalities will have difficulty protecting against them, while the transaction-management costs of internalizing them by the firm may be too costly in terms of administration-management costs. The partnership of firms with government, the latter compensating the firm with subsidies, and/or the government banning certain activities, or forcing firms to produce in a certain way, could be ways to keep the externalities under control.

Bargaining power

A second demand for the trustees that adopt the axiomatic Nash bargaining solution is the assessment of the bargaining power of the stakeholders. Nash originally included the symmetry among bargaining parties in the axioms, implying that the added value in the bargaining solution will be equally divided among all stakeholders. However, if the trustee has to implement the Nash bargaining solution that would result from strategic bargaining, ignoring the bargaining costs, then the trustee would have to allocate the added value across stakeholders, in proportion to their respective bargaining power. Since the strategic bargain among stakeholders or their representatives is an alternative to the trustees' governance, the latter may be pressured to share the added value according to the distribution of bargaining power in response to the competition of strategic bargaining.

One of the contributions of the Nash program has been the identification of the factors that influence the bargaining power in strategic bargaining (Binmore et al., 1986): i) degree of impatience, i.e. the high or low discount factor that bargaining parties apply to calculate the present value of the payoffs whose materialization is delayed during the

bargaining period; ii) time elapsing between the offer and the counter offer, i.e. creating more or less uncertainty among parties; iii) the instant probability that there will be unforeseen circumstances that would force the cancelation of the negotiation process, and agreement is not reached, i.e. differences in information; iv) the preferences of the bargaining parties, especially their respective degrees of risk aversion. In general, more impatient players, shorter delays between offers and counter-offers, higher probability attached to the event that could cancel out the negotiation process, and more risk aversion, all result in a lower share of added value in the agreed solution (lower bargaining power).

These determinants of bargaining power within the Nash program contrast with the view of the determinants of bargaining power in one of the most influential papers on the stakeholders' view of strategy, Coff (1999), for whom the stakeholders with greater power to dispute the wealth created will be those who: "1) are capable of acting in a unified number, 2) have access to key information, 3) have a very high replacement cost to the firm, and 4) face low costs if they move to another firm" (p 122). Acting as a unified number, when that means developing mutual support mechanisms that prolong the time between offers in the negotiation process could, indeed, increase the bargaining power according to the determinants of power in the Nash program. Being more or less informed could give some bargaining advantage if it means a more accurate estimate of the probability attached to the external event that can stop the negotiation. Points 3) and 4) are difficult to reconcile with the determinants of bargaining power identified in the Nash program. First, high replacement cost suggests high asset specificity, and low costs of moving assets to other uses could be synonymous with low specificity, suggesting some contradiction between the two cases considered. Second, in the Nash program the specificity of the assets affects the payoff from the bargaining process because such specificity determines the outside value of the asset, i.e. the lower bound of the Nash-bargained payoff. The bargaining power in the Nash program allocates the added value.

The trustees may have incentives to modify the share of the added value allocated to the stakeholders for reasons of efficiency. From equation (7) above, if the investment in capacity is sunk, one way to get closer to the value-maximizing capacity is by making

the bargaining power α_I as close as possible to 1. Then, one way to increase the rents of the specific assets, and with that increase the incentives of their owners to invest in these assets, could consist of assigning more bargaining power to the owners of specific assets than to the owners of general ones. The recommendation that shareholders voluntarily allocate bargaining power to the employees, as a mechanism to protect the value of their specific human capital, and this way increase the investment in this capital, has been made before (Asher et al., 2005; Blair, 2005; Blair and Stout, 2006; Hoskisson, et al. 2019). However, the condition for the shareholders benefiting from empowering employees is that the increase in value thus created compensates for the reduction in the share of value created appropriated by the shareholders. This means that, in the transition to the stakeholders-oriented value-maximizing firm, the trustees will have to promise a share of the value created to the shareholders, sufficient to keep them as well-off as in the current situation.

One complication from these restrictions on the allocation of added value by the trustees is when there are multiple stakeholders investing in specific assets, and it is impossible to assign high ex post share of added value to all of them as a protection for the value of the investment. The general advice for the team of trustees is, when possible, contract with the stakeholders before the investment in the respective specific asset is made. In many cases, this contract will have to be trust-based, incomplete contracts because the complete and explicit ones are not feasible due to the high transaction costs. This will be particularly important for those assets whose ownership cannot be transferred, such as human capital. One important function of the trustees is then to build reputation and trust by the stakeholders, so that they have incentives to keep investing in the unique assets of the firm. The reference to strategic bargaining and bargaining power may not be the best way to build trust; the symmetry axiom, with equal sharing of added value, may be a more effective way for the team of trustees to credibly commit to avoiding future opportunistic behavior.

Directors and managers as trustees

Coase (1960) compares private law, evolving from judicial decisions (common law) against government intervention, through regulation or statute, as ways of allocating ownership and decision rights on assets in the presence of externalities. Coase argues

that common law judges should, and actually do, allocate rights under the criterion of economic efficiency, i.e. maximizing economic value net of transaction costs. Further, Coase defends that outcomes from judicial decisions will in many cases be more efficient than the regulatory and legislative norms of general application. The list of mechanisms to allocate property and decision rights to maximize social welfare, in dealing with externalities, includes the market (contract), single ownership of complementary assets (the firm), private common law (judiciary decisions), and statutory laws and regulation (norms of general application). The study of the comparative efficiency of common law and statutory law to allocate rights in response to externalities in the use of these rights is beyond the scope of the paper (see Bertrand (2015) for an excellent discussion on this topic). But it may be worth comparing the figure and function of the judge with that of managers and directors as trustees.

It is clear from the discussion that the directors and managers acting as trustees of the joint venture is a situation different from the solution where a firm is created and becomes the owner of all the strategic and non-strategic complementary resources. In this situation, the administrative decisions of the single owner on the uses of the different resources will be an effective way of internalizing the externalities (this single owner could be the group of shareholders that create a corporation and nominate a management team, agents to manage the assets on their behalf). The management and/or directors as trustees could be an alternative when the single ownership of all the assets affected by cross externalities is not feasible, for example embedded human capital, or when in a dynamic setting the ownership of the non-human assets must be dispersed as a way to better protect the value of the specific human capital and induce efficient investment in this capital. In a situation that differs from judicial intervention, the collaboration of resource owners in production takes place on a regular basis, not exceptionally, and it can be expected that the management team permanently involved in managing the collaboration (administrative structure) will be more informed than the judge about the particular contingencies and circumstances around the normal operations of the business. In other words, the "verifiable" information available to the judge, who will have to make decisions, will be more restrictive than the "observable" information that the manager will be able to collect in the direction of the resources.

What will be similar is that the willingness of collaborating resource owners to rely on the common law and judicial intervention, and to rely on corporate trustees, will require confidence (demonstrated competencies in their job to make social value-maximizing efficiency decisions) and trust (that the confidence will not be used in favor of personal or spurious interests). In the case of managers and directors, the confidence will be in the capacity to internally manage the allocation of resources in situations of asymmetric and incomplete information, similar to those faced by the management team as agent of the shareholders. Trust will, however, be more important with the management team as trustees, than when the managers are agents of the shareholders. The reason is that, when managers are agents of the shareholders, the decision of the resource owners to trust the management team will be based on calculation (it is to the benefit of the shareholders to honor the promises in contexts of implicit and incomplete contracts). With managers and directors as trustees, the decision to trust will depend on the credibility of promises of "good behavior" per se (the legal system has responded to the possibility that the stakeholders' social-value maximizing firm needs to adopt an incorporation different from, for example, that of the benefit-corporation, to better differentiate from shareholders-owned and controlled profit-maximizing corporations).

Trust will, in turn, be related to the belief by the stakeholders that participate in the collaboration, that the management team (and the judge), are properly motivated to make socially efficient decisions. The judge, as a public employee, will be subject to hierarchical administrative controls, and to the controls derived from the possibility of appealing the decisions to superior courts, and other counterbalances. In the case of the management team, the motivation to perform the assigned duty, in addition to the possibility of the stakeholders denouncing abuses and non-diligent and/or non-loyal behavior by the administrators to the courts, that will arise from competition. This competition comes in two forms: from other firms that offer substitute products (recall that the viability condition of the joint collaboration is to create at least the same value as the best alternative), or from institutional competition - in particular the possibility of stakeholders strategically bargaining to agree on actions that may end in removing the management team. There are other, less optimistic views on disciplining managers to maximize value (Bechuck et al., 2021), so at this point, the comparative cost-benefit analysis of institutional choices, including transaction costs, appears as the more appropriate approach to the governance of the stakeholders' firm.

Conclusion

There are proposals, in and out of the business community, asking firms to shift their goals and decision-making criterion from shareholders' profit-maximization to stakeholders' value-maximization. The theories of strategy around value creation, value capture, and the stakeholders' approach, are ill-equipped to assess the theoretical and practical implications of a shift in business purpose - they do not consider deeply enough the demands on new governance mechanisms by the networked firm, structured around multiple power-balanced stakeholders, that are being suggested to replace the governance of the still-dominant shareholders' empowered corporation. This paper proposes the "Nash program" as a body of knowledge that can help in the adaptation of theories of strategy to accommodate the new purpose-driven corporation. The Nash bargaining solution is a repeated reference in the theories of strategy but, as in most of the areas where it is referenced, the version under discussion is that resulting from strategic bargaining. This paper argues that strategic bargaining will result, in general, in high direct transaction costs in the process of offers and counter-offers, writing and enforcing contracts that will limit its applicability in business contexts that demand quick responses and flexible adjustments. For this reason, the proposal here is, first, to acknowledge the importance of transaction costs in the theoretical developments within the strategy field, and in the prescriptions for practice, for example the design of governance mechanisms for the purpose-driven corporation. And second, adopting the axiomatic approach to Nash bargaining instead of strategic bargaining, and build on that to design trustees-based governance systems for the new corporation. Much more theoretical work and learning by experience will be needed to progress in the solution to the important implementation problems faced by the purpose-driven corporation; this paper intends to be one step in that direction.

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Appendix. The Nash bargaining solution and the VCA approach

This appendix integrates the framework of the Value Creation and Appropriation (VCA) approach to strategy within the Nash program, with the calculations of business value created proposed by the VCA approach, when prices of inputs and output are part of the Nash bargaining solution.

From the assumption of the VCA approach of constant willingness to pay and constant opportunity costs, it results in $\Delta U(q^*) = \Delta q^* = 0$ (to assure that changes in buyer's utility do not change) and $\Delta w_i^c = 0, i = 1 \dots N$. The terms $\Delta w_i^c = 0, i = 1 \dots N$ mean that per-unit opportunity costs of the inputs used in production stay constant; therefore, opportunity costs of the inputs can still change, but it will have to be for reasons other than changes in unit (marginal) opportunity costs.

From (9) in the main text, the relative change in the average payment per unit of input i, when the unit opportunity costs of the resource inputs do not change ($\Delta w_i^c = 0, i = 1 \dots N$ and therefore $\frac{\Delta x_j^*}{\Delta w_i^c} = 0, i = 1 \dots N$) is equal to:

$$\frac{\Delta w_i^r}{w_i^r} = \frac{1}{w_i^r x_i^*}\Delta\big(\alpha_i(W^* - W_c)\big) = \frac{1}{w_i^r x_i^*}\big(\Delta\alpha_i(W^* - W_c) + \alpha_i\Delta(W^* - W_c)\big) \quad \text{(A1)}$$

Under similar assumptions, the relative change in average price in (A1) is the same as the change in the wealth allocated to the respective resource input in the Nash bargaining solution in Table 2,

$$\frac{1}{w_i^r}\left(\frac{\Delta\omega_i^*}{x_i^*} = \frac{\Delta(S_i(q^*) - w_i^c x_i^*)}{x_i^*}\right) = \frac{1}{w_i^r x_i^*}\big(\Delta\alpha_i(W^* - W_c) + \alpha_i\Delta(W^* - W_c)\big)$$

Therefore, the relative change in input price from (A1) gives an estimate of the relative change in the wealth appropriated by resource owner i.

The term $\Delta\alpha_i(W^* - W_c)$ is the change in the portion of the wealth created appropriated by the respective resource owner, resulting from a rebalancing of the bargaining power

among stakeholders during the corresponding time period (positive for those that increase the bargaining power, and negative for those that reduce it). The term $\alpha_i \Delta(W^* - W_c)$ corresponds to the change in wealth created appropriated by the actor i, given its initial bargaining power. Substituting $W^* = U^*(q^*) - C^*(q^*)$ and remembering that $\Delta U(q^*) = 0$, it happens that $\alpha_i \Delta(W^* - W_c) = -\alpha_i(\Delta C^* + \Delta W_c)$. The change in average input price will be affected by the change in the variable production cost, ΔC^*, and by the change in the value of the outside consumption opportunity for the buyers, ΔW_c.

Adding the changes in average input prices in (A1), each weighted by the input share $\frac{w_i^r x_i^*}{\bar{\bar{p}} q^*}$ we have,

$$\sum_i \frac{w_i^r x_i^*}{\bar{\bar{p}} q^*} \frac{\Delta w_i^r}{w_i^r} = \frac{-1}{\bar{\bar{p}} q^*} (\Delta W_c + \Delta C^*) \qquad (A2)$$

From equation (8) and the assumptions from the VCA that $\Delta U(q^*) = \Delta q^* = 0$, together with the simplifying assumption that buyers do not have bargaining power, $\alpha_B = 0$ (for simplicity of the exposition), we have $\frac{\Delta \bar{\bar{p}}}{\bar{\bar{p}}} = \frac{-\Delta W_c}{\bar{\bar{p}} q^*}$. The relative change in the average unit price paid by the buyers is equal to the change in wealth created by the best outside option, per unit of revenues. Even when the willingness to pay for the reference product remains constant and buyers do not have bargaining power, the average price of output that buyers pay can change if the wealth created by close-substitute products also changes. Substituting in (A2),

$$\sum_i \frac{w_i^r x_i^*}{\bar{\bar{p}} q^*} \frac{\Delta w_i^r}{w_i^r} - \frac{\Delta \bar{\bar{p}}}{\bar{\bar{p}}} = \frac{-1}{\bar{\bar{p}} q^*} (\Delta C^*) \qquad (A3)$$

Equation (A3) is similar to the main equation of VCA (equation (1) in Garcia-Castro and Aguilera, 2014) but with $\frac{-1}{\bar{\bar{p}} q^*} (\Delta C^*)$ instead of $\frac{\Delta q^*}{q^*} - \sum_i \frac{w_i^r x_i^*}{\bar{\bar{p}} q^*} \frac{\Delta x_i^*}{x_i^*}$ that would be the term in the right hand under the VCA formulation. In (A3), the left and right-hand sides are both expressed in monetary terms, while in the VCA approach the left-hand side is expressed in monetary terms and the right-hand side, relative change in output quantity

minus weighted sum of relative changes in input quantities, would be in physical terms. The term $\frac{\Delta q^*}{q^*} - \sum_i \frac{w_i^r x_i^*}{\bar{\bar{p}} q^*} \frac{\Delta x_i^*}{x_i^*}$ in the VCA approach is interpreted as a measure of growth in total factor productivity, TFP; the term in the right-hand side of (A3) is the change in production cost normalized by the revenues collected from the sellers, with sign changed.

If total output produced and inputs unit opportunity costs do not change (by assumption), the total production cost can change only if input quantities change for reasons other than changes in unit opportunity costs. One of these reasons would be, for example, an increase over time in total factor productivity, TFP, from Hicks neutral technological change, so that the same output can be produced with lower quantities of all inputs (a parallel displacement of the production isoquant for output q^*). In fact, it can be shown that for standard properties of the production function, (A3) can be written with a right -hand side as a function of changes in TFP as follows,

$$\sum_i \frac{w_i^r x_i^*}{\bar{\bar{p}} q^*} \frac{\Delta w_i^r}{w_i^r} - \frac{\Delta \bar{\bar{p}}}{\bar{\bar{p}}} = \frac{\Delta TFP}{TFP} \frac{C^*}{\bar{\bar{p}} q^*} \qquad (A4)$$

The right-hand side of (A4) will coincide with the rate of growth in total factor productivity (the expression used in VCA) only when the total production cost is equal to the revenues collected from the buyers, i.e. when profits of the firm are zero[12].

[12] Lieberman et al. (2018) modify the hypothesis with respect to the 2017 paper. In the initial measurement time period, the prices of inputs reflect opportunity costs and the selling price of the output is equal to the marginal cost, i.e. the economic profits of the firm are zero. The conditions for the right-hand side of (A4) coinciding with TFP growth would then be satisfied. During the following time period, the prices are allowed to vary but it is unclear from the paper if the change responds to changes in opportunity costs or for other reasons, and nothing is said about how the change of the prices of inputs affects the demand for cost-minimizing inputs.