ENDOGENIZING TECHNOLOGICAL CHOICE: A MEASUREMENT COST VIEW

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Abstract

Seeking inspiration on the measurement cost branch of the transaction cost literature, the present article explores the agents' incentives to change and/or adopt new technologies of production and of measurement. In order to accomplish this goal the paper explores three directions. Initially, it presents a simplified conceptual model which considers explicitly the costs of capture and protection of property rights as elements that determine the strategies of players. The second part of the paper examines technology as a shifter parameter of the model, exploring how it affects attribute variability, and consequently the ability to capture value. Part three presents examples of efforts to develop technologies and adoption of existing measurement technologies. The paper concludes with some perspective for future investigations.

Key words: measurement costs, technological choice

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1. Introduction

The economic analysis of technological choice and change has found important contributions on the neoclassical theory of the firm. The main argument proposed – and exhaustively tested in the literature – is that technology change responds to price incentives. For instance, as the price of labor increases, labor saving technologies are expected to be chosen.

The present study proposes a different perspective on technological choice based on the measurement cost branch of the transaction cost literature as developed by Barzel (1997, 2002). Under these lenses, the incentives to the players are based on the existence of value generated in joint production efforts. The value created as the result of joint production efforts can be associated to property rights, suggesting that agents in a transaction are expected to take into account the mechanisms of protecting and capturing property rights. Barzel (1997) argues that property rights can be protected by the state (legal rights) or by private mechanisms (economic rights). Unprotected value, in turn, remains in public domain, therefore being subject to capture at no cost. Value can also be subject to capture – however at positive costs – in situations of failures in the legal and economic mechanisms of protection.

The model developed by Barzel considers the existence of a given state of the art in production technology, meaning that variability of inputs and outputs are determined. Moreover, the property rights approach (Barzel, 1997) assumes that measurement technology is given, so that the costs of capture are determined. Seeking to expand this framework, the present paper explores the incentives to adopt existing alternative technologies of production and measurement. In order to accomplish this goal the paper explores three directions:

The initial part of the study discusses the property rights model in two levels. The first is a simplified conceptual model that proposes the existence of a property rights index, defined as the proportion of unprotected on the total protected value (Zylbersztajn, 2010). The index characterizes the incentives of players to protect/capture value and to engage in joint production efforts. The second is a heuristic model which considers explicitly the costs of

capture and protection of property rights as elements that determine the strategies of players (Monteiro and Zylbersztajn, 2011).

The second part of the paper examines technology as a shifter parameter of the models, exploring how it affects variability, and consequently the ability to capture value. Considering the fact that alternative technologies have impacts on strategies, we discuss the agents' incentives to choose among existing technologies, both in production (based on the effect on homogeneity of attributes) and in measurement (based on the reduction of costs to measure attributes). Part three presents examples of adoption of measurement technologies. The paper is concluded by proposing points for future research.

2. The measurement cost approach

The measurement branch of Transaction Cost Economics (Barzel, 1997) suggests that a transaction can be decoupled in many attributes. There are two relevant aspects associated to each attribute. First, an attribute contributes to the generation of value in a transaction, thus creating incentives for value protection and capture. Second, each attribute presents some degree of variability, thus affecting the cost of measurement of the attribute itself. In general terms, the value of an asset in a transaction can be dissipated if the property rights over its attributes are not properly delineated, which can occur if it is hard to measure – and therefore contract for – a given attribute.

Barzel (1997) makes a distinction between legal property rights and economic property rights. The former refers to that which the state "guarantees" to an agent. The latter is the agent's ability, in expected terms, to consume the goods or services associated with a given asset.

Legal rights are the basis of agreements whose enforcement is straightforwardly dependent on the state. Such agreements are outlined as contracts and take place on the market. The state is in charge of setting restrictions with which the contract must conform; once these restrictions are delineated, individuals are free to establish among themselves the most appropriate contract terms to meet their varying needs. Accordingly, formal institutions emerge when the state and the courts play a role to protect the structure of property rights.

Formal institutions are related with legal rights and are necessary to provide incentives for agents who take part in the transaction without personal interaction.

At the opposite extreme to the design of contracts we are faced with non-contractual agreements which are characterized by a less precise definition of the transacted attributes due to high measurement costs associated to variability. The enforcement of these agreements is generally supported by private mechanisms – e.g., a long-term relationship sustained by agents' reputation. These mechanisms are informal since they do not rely on the state. Hence, informal-private institutions are related to economic rights and shape part of the incentives necessary to handle simple, personal and usually local institutional arrangements. Reputation-based mechanisms of exclusion and enforcement of informal rules are at the core of the functioning of informal institutions, and courts are not adopted to solve disputes.

In any case, institutional arrangements represent how the production organizations are governed, including how enforcement mechanisms are shaped (Libecap, 1989). Because the perfect measurement of the attributes of an asset is always costly (Barzel, 1997), contracts explicitly describe some attributes of the transaction, while implicitly delineate others, but do not consider all transacted dimensions, meaning that some value is expected to remain unprotected, subject to be in public domain. Even so, attributes whose measurement is too costly remain part of the transaction. As a result, contracts and long-term relationships can coexist in an exchange process, and the institutional structure of production is the observed result of the joint effects of formal and informal institutions. As stated by Ostrom (2008), no general panacea solution is expected.

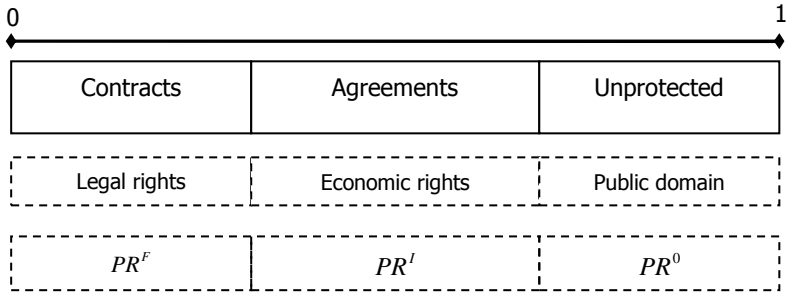
The above reasoning can be rephrased through a simple theoretical formulation. Let's consider an "index of property rights" defined as $PR_i \in [0,1]$. The closer the index is to zero, the less delineated or guaranteed is the right within a particular transaction[1]. The closer to 1, the greater the sum of the institutional and the private efforts direct at protecting property rights.

The index highlights the relationship between the type of norm that governs a given transaction (formal – PR^F or informal – PR^I) and the type of rights that provide support for the transaction (legal or economic). The model considers, moreover, the proportion of

[1] A fisrt version of this theoretical model was discussed in Zylberzstajn (2010).

property rights which is not protected, i.e., the portion of the total transaction value that belongs to the public domain, PR^0. As indicated in the figure below, $PR^F + PR^I + PR^0 = 1$. It is noteworthy that the levels PR^F, PR^I and PR^0 are not fixed, but vary in accordance with the guarantees provided by the institutional environment.

Figure 1: Property Rights Index



When analyzing the incentives for the establishment of a given transaction, we define a critical level of protection of property rights PR_i^* which is enough to shape the incentives of the parties to engage in joint production efforts, defined as transaction *i*. Accordingly, when $PR_i^* < PR^F$ it is expected that the transaction is organized as a contract on the market, and the protection granted by the courts is sufficient for the smooth progress of the relationship. When $PR^F < PR_i^* < PR^F + PR^I$, the transaction tends to be based on some combination of formal and informal norms[2].

While the property rights index model provides a good description of the underlying institutional structure of transactions, it does not directly address the issue of efforts for protection and capture of property rights. The different mechanisms of property rights protection can be investigated through a complementary approach.

As proposed by Monteiro and Zylberzstajn (2011), in order to compare different property rights protection mechanisms, one has initially to consider the costs associated with each particular mechanism. Since protection efforts may involve the recourse to the legal system (L) in the case of formal institutions or the establishment of private mechanisms (P) in

[2] This model assumes the preference of players to adopt legal norms first, and then complement with informal norms. This assumption can be dropped in some cases.

the case of informal institutions, the authors define two functions that represent the costs of protection.

$$L = L(\sigma, w) \qquad (1)$$

$$P = P(\sigma, w) \qquad (2)$$

In the functions, $\sigma \in [0,1]$ represents the relative efficacy of capture in relation to protection, being $\sigma = 0$ a case of full protection. The relative efficacy of capture is closed connected to the concept of *capacity of fighting*, i.e., the capacity that characterizes protection and capture of property rights. This parameter can vary between companies and across time. In addition, *w* corresponds to a set of shifter parameters (e.g., the measurement technology applied in the transaction).

Both L (.) and P (.) are increasing functions of σ: the higher the relative efficacy of the capture, the greater the effort of an agent to secure his or her property rights. Formally, $\frac{\partial L}{\partial \sigma} > 0$ and $\frac{\partial P}{\partial \sigma} > 0$.

Especial attention may be directed at the impact of the institutional environment on the protection mechanisms. In this regard, one should note that in situations where the quality of the institutional environment (*I*) is sufficiently high, the relative efficacy of the property rights capture tends to zero, i.e. $\sigma \xrightarrow{I \to \infty} 0$.[3] In this case, it is assumed that the recourse to formal institutions and the use of the legal system are more efficient than any private mechanism of protection. Specifically, the use of the legal system in a strong institutional environment is assumed to be the most efficient way to protect property rights: $L(0, w) < P(0, w), \forall w$.

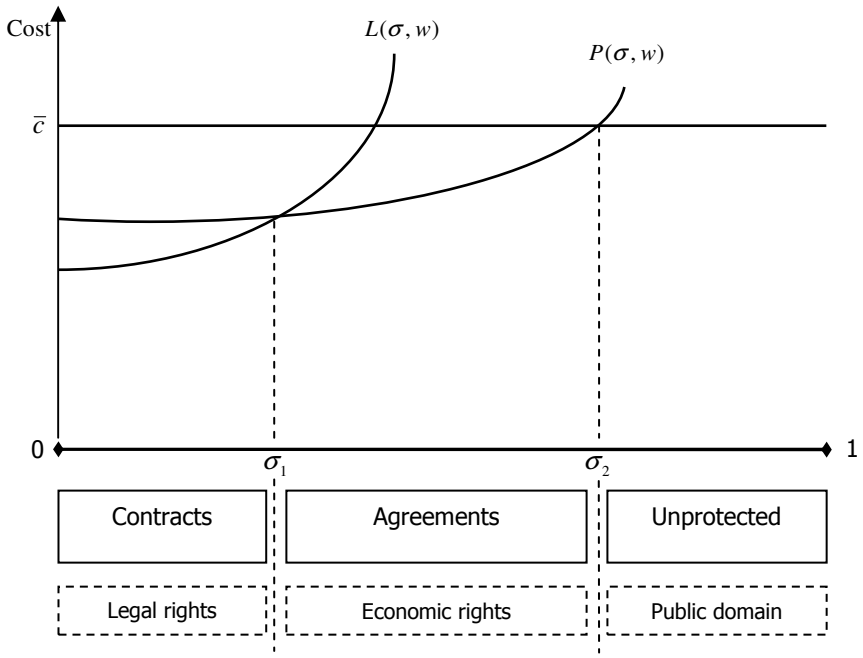
Nevertheless, as the quality of the institutional environment decreases, the relative efficacy of the capture increases and the effectiveness of the legal system in providing property rights protection is reduced. In a weak institutional environment, the judiciary tends to be inefficient and time consuming, being inconsistent with the demands required for the efficient performance of trade relations. Thus, as the quality of the institutional environment

[3] Formally, it is easy to see that $\frac{\partial \sigma}{\partial I} < 0$.

is reduced, the cost of using the legal system increases relatively more compared to the cost associated with a private mechanism of protection: $\frac{\partial L}{\partial \sigma} > \frac{\partial P}{\partial \sigma} > 0$. As result, informal institutions may become more prevalent.

Based on the above discussion, we can construct the figure below which shows the protection costs varying according to the relative efficacy of capture (σ). The figure also shows the cost level $\bar{c}$ which represents the maximum cost of protection that a firm can bear[4].

Figure 2: Protection of property rights



In the figure, the level of efficacy of capture σ_1 is such that the firm is indifferent to protect property rights through recourse to the legal system (legal rights) or through a private mechanism (economic rights). On the other hand, the level of efficacy of capture σ_2 is such that the firm is indifferent between establishing a private mechanism (agreement) and abandoning the valuable attributes in the public domain. In the case of abandonment of the

[4] For simplicity, we assume that c is constant. This hypothesis, however, does not affect the overall outcome of the analysis.

attributes, institutional conditions are so adverse that the cost of protection is greater than the maximum cost $\bar{c}$, and the firm's optimal option is to undertake no protection effort and let other agents eventually capture the valuable attributes. In general, the efficient response of economic agents corresponds to the lower envelope of the cost curves expressed in the figure.

The players can adopt a solution characterized by $\sigma > \sigma_2$, meaning that some value remains in public domain, but yet there are incentives to perform the transaction. Taking into consideration the model described in Figure 1, it means that the critical level of protection is fulfilled, and the players are willing to engage in joint production efforts.

Concerning the area between σ_1 and σ_2, it is worth mentioning that there is not a single private mechanism of property rights protection, but a collection of policy or strategic options whose relative efficiency varies in space and time. In more formal terms, one can say that each point on the curve represents a different type f agreement. A common feature of these points is that agents in a transaction believe that the design of a particular, informal governance structure enables the emergence of property rights that are best protected in comparison with the protection granted by the state[5].

It should be noted that the above description is largely dependent on the technological characteristics of production and measurement which determine the conditions of the transaction. The model considers the existence of a given measurement technology, so that the incentives for the capture and protection of property rights are determined. In what follows, the authors investigate how technology may be examined as a shifter parameter of the model.

3. The role of technological choice

In the previous section it was argued that every transaction is characterized by a broad set of attributes or dimensions. Certain attributes of the transaction are exchanged based in contracts, being governed as legal rights (formal institutions). Other attributes, because they

[5] Barzel (2001:9) notes that *"organizations are formed for the express purpose of creating rights that are more economically enforced by non-state means than by state means"*.

are more expensively measured, are transacted in the form of agreements between the parties (economic rights). Finally, some attributes are abandoned in the public domain, being unprotected. As demonstrated by the model, each organizational solution is associated with a cost of protection which varies in line with the relative efficiency of capture (σ).

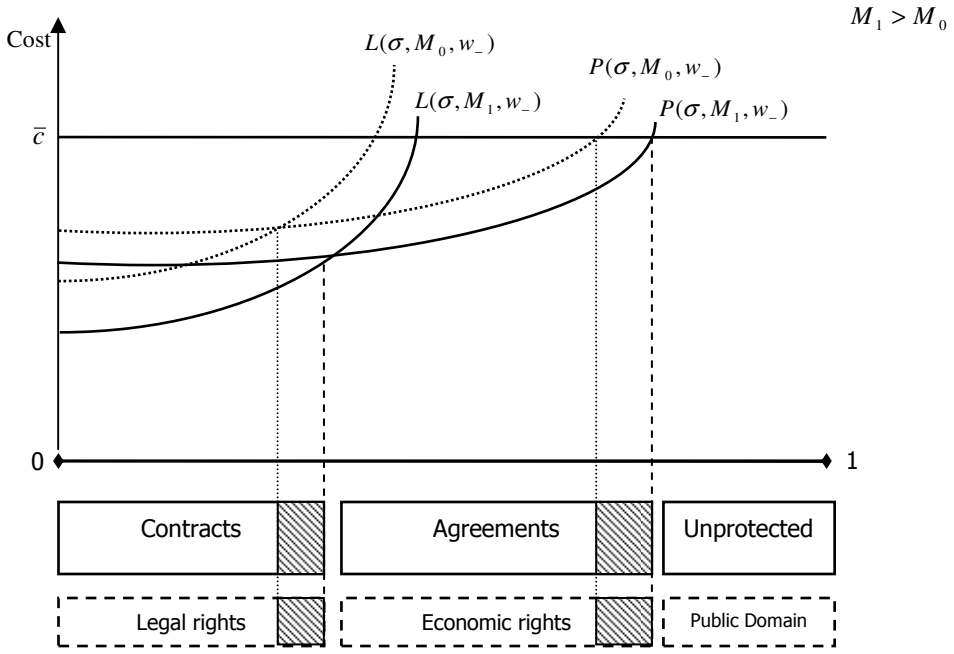
One feature of the model is that the functions which represent the cost of protection are characterized by underlying assumptions on the technology of measurement and production, with implications to the variability and measurement cost of attributes. It is assumed that the courts, in the case of protection through the legal system (formal institutions), and the parties in a transaction, in the case of protection through private mechanisms (informal institutions), operate within a given measurement technology. The courts can only ensure protection of attributes which can be measured; this is the scope of the legal rights. Agents in a transaction, on the other hand, delineate economic rights taking into account the attributes subject to (indirect) measurement within the recurrent transaction. Accordingly, the change in production and measurement technologies alters both, the ability of the courts to measure attributes, and the ability of agents to implement private mechanisms of protection.

One can assert that an improvement in measurement technology increases the efficiency of the courts in identifying transaction attributes. This extension of the protection provided by the courts expands the scope of the legal rights and of the contract associated with a particular transaction. As a result, the change in measurement technology affects the decision to transform the agreement based on private guarantees into a contract based on legal rights guaranteed by courts.

An improved measurement technology also increases the possibility of agreements between the agents in a transaction, enabling the incorporation into the transaction of at least a portion of the dimensions previously abandoned in the public domain. The figure below illustrates these aspects. One may note that a technological change that makes the measurement more costly would have the opposite effects as described below[6].

[6] Similar rationale applies to the effect that production technology has on attributes variability. Therefore new technologies will also change the relative efficacy of capture.

Figure 3: Improvement in the measurement technology



As a general result, measurement technology changes through time affecting the transaction process and the measurement costs of attributes. If costs are reduced, then a new efficient solution emerges. Incentives to adopt a specific measurement technology are related to specific impacts on the ability of transactors to protect value, not considering government intervention. The existence of private or public standards also affect the efficient solution, since given the existing measurement technology, the enhanced homogeneity reduces the measurement costs. Standards, being public or private, have a selective effect in the technology of production. Finally, the competence of courts to handle disputes is also affected, since given the measurement technology adopted, the efficient decision is affected by the way disputes are handled by the state.

The analysis on the technological change opens room for empirical analysis. The improvement on the measurement technology is related to (i) the expansion of the scope of contracts in a transaction, and (ii) the incorporation in the transaction of dimensions which were previously placed in the public domain. Likewise, we can test hypothesis related to the efforts applied to technological choices in production, with some effect on the variability of attributes. In such cases, agents will have incentives to promote technological choices that

bend the efficacy of capture in their favor. Specifically we can state that (iii) agents will promote technological changes that affect variability of attributes, enhancing the capacity of courts, and (iv) they will make efforts towards technological changes that facilitate mechanisms to set agreements. In both cases, technological changes and technologies of measurement are considered as strategic variables, being therefore endogenously determined.

4. Illustrations

This section presents two examples to illustrate the model, all considering experiences in the agro-based production systems. The examples encompass the adoption of standards, and the development of technology to measure attributes.

Case 1: Standards Adoption

The market for fresh food, mainly vegetables, is an example of a complex system of interconnected transactions. Agents are geographically dispersed and the product moves through a long supply chain. Tomatoes is one of the important products in the Brazilian market for fresh vegetables, and a large part of the national production moves through the Central Market of Sao Paulo (CEAGESP), which is among the largest markets in the world.

The study of Lucci (2007) discussed a particular condition where the public standard system is rejected by players who operate in CEAGESP. The adoption of standards is voluntary and is based on easy to measure product characteristics. The prevailing system, on the other hand, is a private mechanisms described as a set of standards that "vary every day". In other words, the grade A observed in day 1, might differ from the same grade A in the following day. It depends on the demand conditions.

Figure 3 shows a possible interpretation of the existing systems of standards. Players that operate in the wholesale market of fresh vegetables in the city of São Paulo choose the standard that preserves larger variability, increasing the value in public domain and therefore the potential of capture. Costs of protection of value by farmers increase. The alternative public standard, once adopted, would reduce variability, amplifying the feasible range of legal enforcement. The players have incentives to avoid the proposed solution, preferring to keep the non standard practices.

Case 2: Measurement of Attributes

In agro-based systems, the transaction between the processing industry and suppliers is largely dependent on measurement of variability. Usually standards evolve and, in many cases asymmetric information prevails, rising problems of capture of value.

In Brazil the orange processing industry is important, since it supplies 50% of the world market and holds a production structure of 690,000 hectars of orange that supply the industry every year. The characteristic of the orange agribusiness systems is of a strong concentration of the processing industry, which is partially integrated backwards, producing about 30% of its needs. Annual contracts are the governance mechanism that prevails between growers and industries. The efficacy of existing coordination mechanisms are much below acceptable levels, which is signaled by tensions between agents in the chain. Coordination failures are exemplified by the adoption of technologies not accepted by the international markets and also by frequent cases of disputes between farmers and industries, reaching the courts (Azevedo, 1996).

The transaction between farmers and industries is based in contracts being the price paid affected by the international prices of the orange juice concentrate. The market prices and contracts are defined based on the standard of "boxes" of orange. It means a container that has the capacity of "around" 40.8 kilograms of the fresh fruit. The industry extracts the "solid soluble" from the fresh fruit, which once dehydrated, goes to the international market in the form of orange concentrated extract.

Similar transaction in the US industry is based on the content of "solid soluble" of the sample being delivered to the industry. Solids can be measured at low cost with the existing technology of measurement. The sugar-cane industry performs the same transaction being the payment based on the measure of solids instead of weight. The question then is why the orange industry does not adopt the measure based on the sugar content? To answer this question we can use the property rights model presented in figure 3. The difficult to measure unit of transaction, the box, introduces elements of asymmetry of information, leaving value in condition to be captured by the industry.

In the absence of relational mechanisms, economic rights are not in place. Farmers have no option, but to deliver to the industry. Reputation-based mechanisms did not evolve and the transaction is characterized by site specific investments done by farmers. The

adoption of alternative mechanism of payment might lead to redistribution of value from the industry to the farmers, therefore the industry is reluctant to change the form of payment. The contracts are defined unilaterally and farmers can barely negotiate contract terms, being exposed to ex-post hold up risks.

This case exemplifies the choice of a technology of measurement that increases the cost of protection of value. Farmers have shown no capacity to promote the change in the choice of measurement technology.

5. Concluding Remarks

The present paper contributes to the property rights approach. It presents a model that relies on the concept of cost of capture and cost of protection of value, investigating the agents' incentives to adopt available measurement technologies. The model is a consolidation of the existing literature, achieved by explicit consideration of joint operation of two mechanisms of property rights protection as proposed in Barzel (2002), namely legal rights and economic rights. Therefore the conceptual model presented in the first part of the paper considers the costs of capture and protection of property rights as elements that determine the strategies of players. The second part of the paper examines technology choice as a shifter parameter of the model, exploring how it affects attribute variability, and consequently the ability to capture value. Part three presents examples of efforts to adopt existing technologies to measure transaction attribute in agro based transactions (orange and tomatoes).

The main conclusion is that the property rights model present potential explanatory power to address strategic aspects of technology choice. It also opens room for future studies on incentives of technological change based on measurement costs instead of relative prices. As a research agenda, future studies should deepen the understanding expressed in this study that the improvement on the measurement technology may be related to both the expansion of the scope of contracts in a transaction, and the incorporation in the transaction of dimensions which were previously placed in the public domain. The empirical challenges are enormous, but the advancement of the theory of property rights demands this effort.

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