ON THE SURVIVAL OF CONTRACTS: A STUDY OF CONTRACT STABILITY IN THE BRAZILIAN SEED INDUSTRY

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ON THE SURVIVAL OF CONTRACTS: A STUDY OF CONTRACT STABILITY IN THE BRAZILIAN SEED INDUSTRY

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ABSTRACT
Contract length or duration is analyzed in the transaction cost economics literature within an ex ante focus, when agents pre-specify the desired duration of the transaction as a contractual clause. The present study focus on contract duration as defined in an ex post approach, meaning that the “survival” of contractual relationships is observed over time. Analysis of event histories (hazard functions) is employed to operationalize contract duration with an ex post focus. This study describes mechanisms inducing contract stability (i.e., low rates of contract breach) and adaptation based on four elements: characteristics of the transaction, governance mechanisms (control and incentives), the impact of external disturbances, and the role of intellectual property rights. This theoretical framework is tested, being in general supported, using data in the Brazilian seed industry, in particular technology licensing contracts between seed companies and the Brazilian Federal Agricultural Research Organization (EMBRAPA).

Key Words
Contract duration, long-term contracts, transaction cost economics, survival analysis, seed industry.

São Paulo, November 1999

1 An earlier draft of this paper was presented in the Inaugural Conference of The International Society for New Institutional Economics, September 1997, held at Washington University in St. Louis, and benefited from comments by Oliver Williamson, Elizabeth Farina, and Paulo Furquim de Azevedo. The cooperation of Dr. Ciro Scaranari and Dr. Edison A. Bolson - Serviço de Produção de Sementes Básicas from EMBRAPA and Fabio Takaki, research assistant, is gratefully acknowledged. We have well-defined property rights over remaining errors and omissions.
1. INTRODUCTION

Departing from polar cases of markets or hierarchies, “hybrid” contractual forms represent an important governance mode in many industries. This is the case of transactions involving technology transfer in plant and animal genetics, characterized by a complex interplay between the institutional environment (North, 1990), in particular the structure of intellectual property rights, and governance structures (Williamson, 1985) devised by firms to support continuous relations among players.

Long-term contracts intend to replace other governance forms were parties desire a certain degree of hierarchy-like control of transactions but at the same time arrangements that preserve flexibility and market-like incentives (Williamson, 1991). However, the assumption of contract incompleteness makes contractual duration, stability, and breach important issues since it is not possible for the parties to anticipate all future contingencies. It follows that the design of long-term relationship must be sensitive to the necessary adaptations demanded for its continuity.

Contract length is analyzed in the transaction cost economics (TCE) literature, but the focus is often on an *ex ante* moment, when agents pre-specify the desired duration of the transaction as a contractual clause (e.g., Joskow, 1987; Crocker and Masten, 1988). The present study focus instead on contract duration as observed on an *ex post* moment, meaning that we are evaluating the “survival” of contractual relationships over time. In this sense, one contribution of this study is the application of methodologies for the analysis of event histories (Petersen, 1993; Kiefer, 1988) to the duration of contractual arrangements. Another contribution is an attempt to unpack mechanisms in which commercial relationships evolve over time, an issue that has received little attention by TCE scholars (Williamson, 1993, p. 94).

In the present study, the theoretical discussion on contract duration and adaptability focuses on four elements: characteristics of the transaction, governance mechanisms (control and incentives), the impact of external disturbances, and the role of intellectual property rights. This discussion is followed by an empirical analysis in the

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2 Silverman et al. (1997) applied analysis of event histories using TCE arguments, but they were concerned with the impact of TCE-consistent strategies on the survival of *firms*, rather than one particular form of governance.
Brazilian seed industry, specially technology licensing contracts in the corn market between seed companies and the Brazilian Federal Agricultural Research Organization – EMBRAPA – which develops new plant varieties. Hypotheses are tested based on data from these contracts using analysis of event histories (hazard functions).

The study is organized in five sections. The second reviews theoretical aspects related to contract duration and adaptability. In the third section, the contractual structure of the Brazilian seed industry is presented, with emphasis on EMBRAPA’s licensing contracts. The fourth section formulates and tests specific hypotheses related to these contracts. The final section concludes.

2. CONTRACT DURATION: THEORY

2.1. Long-term Contracts

TCE scholars consider long-term contracts as mechanisms to motivate parties to make specific investments while avoiding costly vertical integration (Williamson, 1985; Klein et al., 1978). Since post-contractual opportunism may induce hold-up, as quasi-rents emerge from specific investments, safeguards should be employed. Possible ways to deal with hold-up risk are commitments made by both parties by either creating bilateral dependence or credible signals of effective interest in the continuity of the contract.

This basic claim has been supported by several empirical studies. Pittman (1991) discusses contractual transformation applied to railroad contracts, evidencing mechanisms to deter opportunistic behavior in the presence of specific investments. Crocker and Masten (1988), studying unilateral breaches in contracts of natural gas, conclude that the willingness of parties to enter long-term contracts is limited by hazards inherent in the exchange (p. 341). As emphasized earlier, contract duration is treated as an exogenous variable defined ex ante by the parties engaged in contracting.

A series of studies by Joskow (1987,1990) focused on contract duration as well as price adjustments to support adaptation of long-term arrangements (Joskow, 1988). Again, duration is defined as an ex ante variable, found to be positively influenced by the degree of asset specificity characterizing the transaction – which is consistent with TCE-based propositions. The 1988 study brings a more dynamic setting, discussing long-term
adaptations to changing market conditions, especially prices and quantity adjustments. Joskow argues that if long term contracts cannot be self-enforced or enforced by institutional safeguards, then inefficient *ex post* haggling may occur. The author considers that the observed duration of contracts might differ from the original plan, either due to bilateral negotiations or as a result of contractual hold-up.

Klein (1992) develops a probabilistic framework where contractual hold-ups, induced by opportunistic behavior, occur when unanticipated changes in the environment destabilize a particular contractual relationship. The author develops the concept of self-enforcing range within which the players will be motivated to follow contract clauses if the benefits from continuation are higher than the gains from contractual breach, hence bringing into play the role of private enforcement, or self-enforcing mechanisms.

The problem with this literature is that, in many cases, contractual breach occurs as a result of unanticipated changes that are not adequately handled by the existing contract, not necessarily due to opportunistic behavior or hold-up problems. Defining contractual hold-up as a violation of intent, contractual breach should not be necessarily defined as resulting from opportunistic behavior or appropriation of quasi-rents.

Moreover, the continuation of a series of short-term contracts between two parties can be seen as an informal (i.e., with duration not specified *ex ante*) long-term contractual arrangement. Thus, in this study we consider contract duration as an *ex post* variable. The literature on sequential short-term contracts has focused on conditions in which this type of arrangement can be more efficient than a pre-specified, long-term contract. In a principal-agent setting, Fudenberg et al. (1990) show that this occurs, among other things, when “the principal and the agent share the same beliefs about the payoff-relevant future.” (p. 2). However, it is difficult to find actual situations in which this condition in fact occurs, and maybe this is a reflection of the lack of empirical content of this literature. A perspective more aligned with our analysis is brought by Schwartz (1992), who emphasizes the impact of changing economic circumstances on long-term contracting. This motivates a careful analysis of the mechanisms in which parties can promote successful renegotiation and contractual adaptability.

### 2.2. Adaptability Revisited
Considering reasons for contractual breach other than opportunistic behavior, while at the same time considering the possibility and the implications of this type of behavior, the question of adaptability gains importance as an important factor inducing contract continuity. Williamson (1991) has provided a useful way to operationalize adaptability. Departing from the apparently conflicting organizational perspectives by Hayek and Barnard, the first dealing with spontaneous adaptability based on prices and the second dealing with induced adaptability based on control mechanisms, Williamson successfully proposed the combination of both perspectives as distinct ways to govern transactions. Long-term contractual arrangements, more specifically, can be seen as a “hybrid” governance mode supported by both incentives (spontaneous adaptation) and controls (induced adaptation).

Therefore, a complete examination of these arrangements requires a systemic analysis of both market-like incentives (often neglected by the TCE literature, the exception being Joskow, 1988) and hierarchy-like controls (neglected by the principal-agent literature) comprising the governance of the transaction. Provided the autonomy of parties in long-term contracts, mechanisms must be developed to promote adaptation in the presence of external consequential shocks or disturbances and guarantee an alignment of incentives. A special role is played by the institutional environment, posing constraints in agents’ interaction (North, 1990) and therefore influencing the costs to enforce a contract and the benefits to breach it.

The characteristics of the transaction should also influence stability especially with regard to specific assets and imperfect measurement. Unilateral investments in specific assets by one party invite opportunistic behavior by the other party, but not necessarily if the latter has also an interest in the continuation of the relationship. Indeed, in a bilateral relationship, specific investments can induce stability through their effect as “hostages” (Williamson, 1985). Imperfect measurement (Barzel, 1989), in turn, implies that information obtained from experience, or past interaction, can be relevant to reinforce the relationship. This is a clear departure from principal-agent models that establish conditions in which “history” regarding past actions is irrelevant (e.g., Fudenberg et al., 1990).
In sum, four important factors seem to be relevant to support hybrid arrangements: the characteristics of transaction, the existence and type of external disturbance, the incentive and control mechanisms to deal with adaptation, and the effect of the institutional environment. The remainder of this paper applies and tests this theoretical framework in the context of the Brazilian seed industry.

3. CONTRACTUAL ARCHITECTURE IN THE BRAZILIAN SEED INDUSTRY

3.1. Overview

Figure 1 depicts the seed supply chain with its main players and transactions. The first player is the R&D company, which develops new plant varieties through traditional breeding or biotechnological processes. Both state-owned (including EMBRAPA) and private enterprises operate at this level. The second agent is the commercial seed company (also called “seed multiplier”) whose basic function is to multiply the highly productive varieties or hybrid seeds obtained from R&D companies (T1), in order to produce commercial seeds to be sold to growers. The third agent is the farmer, who buys seeds as an input for agriculture production (T2) or uses saved seeds from former seasons (T4), and then sells the output to elevators or processors (T3).

The transaction focused on this study is T1, which represents an exchange between two specialized agents, the first producing technology and the second buying or licensing technology and producing seeds. This transaction is subject to a high level of uncertainty regarding the appropriability of the innovation, since the seed itself carries the relevant technology: once placed in the market, the product can be multiplied and sold making it very difficult to exclude free riders and to protect intellectual property right. In this sense, one could hypothesize that T1 should be hierarchically governed. Indeed, some firms are vertically integrated in this process, accomplishing R&D and marketing their own commercial seeds to growers. In this hazardous environment, how to explain the shape of the licensing contract between EMBRAPA and seed multipliers?

There are two types of technologies with different biological characteristics affecting the contractual design in these markets. First, hybrid seeds have their property
rights “naturally protected”. No seeds harvested from one generation of plants will carry the original genetic potential in future generations, reducing the growers’ benefits to save their own seeds, and other agents’ benefits to multiply illegally (i.e., without payment of royalties) the seeds obtained from the R&D company. This is the case of corn, the product focused by EMBRAPA’s licensing program. The second case is represented by plant varieties (*non-hybrids*), such as soybeans. In this case, the very same genetic characteristics will be maintained in future generations in such a way that proper enforcement of property rights needs other instruments. Therefore, a “tighter” appropriability regime (Teece, 1986), induced by the nature of corn seeds, helped to support contractual stability with regard to intellectual property rights in EMBRAPA’s program.

On the other hand, in the case of non-hybrids, this discussion suggests that market transactions will not be an efficient arrangement especially when there is no support in the institutional environment with respect to the enforcement of intellectual property rights, such as in Brazil until 1998. This point will be further discussed in section 3.3.

### 3.2. EMBRAPA’s Licensing Program

In 1987, EMBRAPA decided to launch a licensing program with a group of small seed companies. As common characteristics, these companies did not have their own research departments, and were limited to the multiplication of varieties of public-owned varieties of soybean, bean, rice and other commodities. The licensing contract allowed the companies to enter the market for hybrid corn seeds, which was mostly occupied by large companies with their own R&D departments and strong brand names operating in an oligopolistic market. The contracts were of limited length (1 year) but expected to be automatically extended. Thus, this seems to be a case of a series of short-term contracts defining an evolving long-term relationship.

Corn seeds, beginning with a hybrid called “BR-201”, were transferred to the companies allowing them to produce hybrid seeds under strict control of EMBRAPA. The

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3 We are not arguing, however, that “natural” protection for some seeds implies that there will be only market-organized transactions. Some firms are vertically integrated in the stages of R&D and seed multiplication even in the corn market. Rather, we argue that this is a characteristic supporting the stability of EMBRAPA’s licensing program.
definition of technical standards was part of the contractual agreement between each seed company and EMBRAPA. This organization also defined that marketing activities should be independently carried out by the licensees, i.e., they should bear the costs of promotion and sales. The hybrid brand name should necessarily be stamped on the seed bag. Each company was required to have properly trained human capital. In general, companies had already been operating in the seed market, therefore holding investments in equipment for seed processing.

Contractual safeguards were defined, allowing EMBRAPA to breach the contracts if payments were not properly handled, sub-licensing observed, or non-satisfactory technical standards detected. The license fee for each kilogram of seed obtained from EMBRAPA, or “royalty”, was defined annually as a function of each licensee’s productivity or farm yield (amount of seed produced, or multiplied, over the total amount obtained), performance in terms of sales, and the market price of the commercial seed. No specific territories have been defined for the companies, allowing internal competition between the licensees in the program.

This design allowed the licensees to gain a market share of about 15% in the hybrid corn seed market in the first years of operation. Other seed companies also started to practice similar licensing procedures. For EMBRAPA, the program brought extra resources to be invested in further R&D projects, but at the same time the need to manage a new and complex contractual arrangement.

3.3. Intellectual Property Rights: Some Comments

In the seed industry, the UPOV convention regulates the property rights of the technology developed by geneticists and plant breeders, providing guidelines for national-based legislation and enforcement in signatory countries. Plant breeders’ right legislation is the common term to denote the institutional structure to support intellectual property rights in plant genetics. Several countries have adopted UPOV-like legislation to regulate plant breeders’ rights. In the U.S., a specific legislation has been in place since 1930 – the Plant Patent Act – which was extended and adapted in 1970 with the design of the Plant Variety Protection Act.
The most common approach to study plant breeders’ rights is based on monopolistic arguments, pointing out the possible impacts of this institution on market structure and prices (Lesser and Masson, 1983; Butler and Marion, 1985). Efficiency-based aspects of the implementation of plant breeder’s rights have been largely neglected in the literature, except in some exploratory studies (Zylbersztajn and Silva, 1992). Loose property rights impose high transaction costs for firms investing in plant genetics R&D and reduce incentives for further investments.

More specifically, one characteristic of transactions involving technology transfer in plant genetics is a high level of monitoring costs, even higher than the costs related to the enforcement of patents for most technologies. The reason, as discussed earlier, is that the seed itself carries all the technological content. Critics of plant breeders’ rights have considered the distortions imposed by the temporary monopolistic power resulting from the legal definition of property rights, and enthusiasts have stressed the dynamic effects of the increase in the rate of technological development. Few scholars have considered its effects on the organization and contracting in the industry.

Brazil approved a plant breeders’ rights legislation in 1998. Following Perrin et al. (1983), it is possible to predict that the change in the structure of property rights will motivate new contractual arrangements in the seed industry. In particular, the new legislation can increase the adoption of hybrid governance structures. Some companies can specialize in R&D while others in seed multiplication and marketing. Even companies that define a strategy to maintain R&D and marketing activities can also license hybrid lines or varieties when they are no longer of strategic interest. Anticipating the institutional change in Brazil, some companies were already planning the introduction of even non-hybrid seeds (such as soybeans) through contracts with seed multipliers.

**4. CONTRACTUAL STABILITY: AN EMPIRICAL ANALYSIS**

**4.1. Propositions**

Section 2 emphasized four relevant factors inducing contract stability: characteristics of the transaction, external disturbances, governance mechanisms

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4 UPOV refers to the International Union for the Protection of New Varieties of Plants. It is an
promoting adaptability (incentives and controls), and the role of institutions. The fourth issue was discussed in the former section. The objective of this section is now to discuss the first three factors in the context of EMBRAPA’s licensing contracts.

Anecdotal evidence indicates that contract breaches were induced by both EMBRAPA (justifications include licensee’s default, non-satisfactory technical standards, and unauthorized practices such as sub-licensing) and licensees (spontaneous departures, commonly justified by a lack of interest in the hybrid or difficulty with sales). Despite this evidence, we believe that more insights can be obtained from a microanalytic examination of variables that might influence the stability of the arrangement. Moreover, given the bilateral nature of this relationship, we consider contract breach regardless of who induced it. This allows us to analyze the contractual arrangement in a complete manner, meaning that both parties will tend to continue the relationship provided certain characteristics of the transaction are met, governance structures aligned, and external disturbances properly handled.

With regard to the characteristics of the transaction, two aspects are relevant. First, high performance in the production and commercialization of the hybrids requires technical and commercial expertise, as well as marketing and sale expenses, part of which dedicated to the relationship with EMBRAPA. This organization, in turn, also presents specific investments associated with the technology under licensing and its brand name. Since these investments are likely to lose part of their value if applied to other uses, they represent a factor inhibiting contract breach by both parties. Second, imperfect measurement of licensees’ actions (for instance, sale efforts) requires the observation of performance proxies obtained from past experience with a given a licensee. Thus, being induced by specific investments or not, a high past performance should decrease the likelihood of contract breach.

The presence and type of external disturbances can also be considered a characteristic of transaction (indeed, Williamson, 1991, calls this factor “uncertainty”), but we are discussing it separately in order to highlight its importance. One crucial issue that we identified is related to local market conditions faced by licensees. Since the contract international convention with headquarters in Geneva.
did not specify exclusive territories, in some regions we could find several licensees competing for the same local market. Site specificity is important in this context, because the licensees hold specific investments associated with their regional markets (distribution channels, knowledge of clients, commercial structure, and so on). Predatory competition was indeed a problem, with negative consequences for these local investments since loose property rights over territories tended to increase uncertainties falling upon licensees’ businesses. Williamson (1991) maintains that, in the presence of specific investments, high uncertainty tends to destabilize long-term contracts. Thus, we propose that a low market concentration in a certain region, associated with high competition between licensees, tend to increase the likelihood of contract breach.

The final element in our discussion is represented by governance mechanisms to promote contractual adaptability. Incentives are essential to promote autonomous adaptation, and are represented in this contract by the payment of royalties. As discussed earlier, EMBRAPA has calculated royalties based on the annual licensee’s performance in terms of sales, productivity, and average price to growers. However, variations tended to occur. Principal-agent considerations suggest that if licensees are “overcharged” (i.e., an actual level of royalty higher than the expected level based on these three variables), they will be more likely to leave the relationship. This prediction is also supported by social comparison theories emphasizing that agents will feel dissatisfied and inclined to leave if they perceive that their peers are receiving a higher compensation/performance ratio (Adams, 1965).

In terms of control mechanisms, it should be pointed out that safeguards, monitoring and enforcement clauses specified by the licensing contract are fairly standardized in this relationship, so we do not expect variations between licensees. However, one aspect tend to vary between licensees: the existence or not of multiple contracts with EMBRAPA, provided there were several hybrids in the licensing program (BR-201, BR-205 and BR-206). As suggested by de Figueiredo and Teece (1996), the existence of multiple contracts tends to generate “bundles of safeguards” (p. 544) against behavioral hazards. In our case, it tends to be easier for EMBRAPA to enforce the contract with the threat of termination of more than one contract. Hence, we expect that
the existence of multiple contracts (as opposed to a single one, the BR-201) reduces the likelihood of contract breach.

4.2. Data

This study uses a panel data set from 34 contracts of EMBRAPA’s corn seed licensing program from 1991 to 1996, regarding the hybrid BR-201. The program was started in 1987, but we have detailed information departing from 1991 only\textsuperscript{5}. Notice, therefore, that the unit of analysis in this study is a particular transaction (\(T_i\) in Figure 1) observed over time. Considering that some companies joined the program after 1991, we have a total of 141 observations.

4.3. Model

We want to model a situation in which contracts are “at risk” of being breached, or continued in a given moment. A simple qualitative dependent variable model (such as Probit), by predicting the probability of breach according to exogenous variables, would be able to model causes of breach, but not temporal influences that might be important. If we include contract duration as an exogenous variable to explain breach, we would be using what we want to predict as a predictor, which is unreasonable (Petersen, 1993, pp. 455-56).

In this sense, hazard rate functions seem to be more appropriate for the present problem. In a continuous time specification, a hazard rate function \(\hat{h}(t)\) measures the rate at which a contract will be breached at a given date \(t\) conditional on the fact that the contract was not breached (or “survived”) up to this date. Time (in our case, years) since the beginning of the contractual relationship with EMBRAPA defines the duration \((t)\) of a given licensee’s contract. In the Cox proportional hazards specification, the hazard function \(\hat{h}(t)\) is decomposed in two parts, as follows (see Kiefer, 1988):

\[
\hat{h}(t) = h_0(t) \phi(\beta, x)
\]

\textsuperscript{5} Even though we have information about other hybrids (BR-205 and BR-206), we did not include them in the sample because their licensing contracts have a smaller number of observations (they were introduced later and for a restricted number of companies), and information regarding the existence of these contracts enabled us to evaluate some features of the BR-201 contract, by far the most important in terms of sales. Namely, the existence of contracts for other hybrids between EMBRAPA and a given seed company was used as an indication of multiple contracts as a control mechanism.
where \( h_0(t) \) is a duration-dependent component (the “baseline” hazard function), and \( \phi(\beta, x) \) is a function which does not depend on the duration \( t \), being specified by a vector of exogenous variables \( x \) and unknown coefficients \( \beta \). Of particular interest here is the last component, which allows us to model the effect of exogenous variables and test the propositions presented in item 4.1. We assume an exponential specification for this component:

\[
\phi(.) = \exp(\beta_1 x_1 + \ldots + \beta_k x_k)
\]

Given the nature of the data, the vector of exogenous variables \( x \) is defined both temporally (time-series for a single licensee) and in cross-section (observations of several licensees at a given date). Thus, the exogenous variables are all time-varying, being observed every year. Contracts that were not breached until the last year of analysis (1996) constitute “right-censored” observations, and are properly controlled in the estimation process\(^6\).

### 4.4. Measures

We use the following measures of characteristics of the transaction:

- **Quantity** measures the quantity (kg) of seed obtained by the seed multiplier from EMBRAPA in a given year. Licensees who obtain high amounts of seed from EMBRAPA are likely to present a higher level of specific investments, including technical knowledge, marketing and sale expenses associated with the hybrid. Moreover, unitary monitoring costs for licensees who obtain larger amounts of seed tend to be lower. Thus, we should expect **Quantity** to be negatively related to the likelihood of instantaneous breach.

- **Sale efficiency** measures the proportion of the licensee’s sales (kg) in a given year over the total BR-201 seed obtained from EMBRAPA in this particular year\(^7\). This

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\(^6\) Even though the licensing program was started in 1987 and we have only detailed information from 1991, we know the first year when a given company joined the program. Thus, “left-censoring” (unknown entry dates) is not an issue here, provided temporal ranges are also properly controlled in the estimation process.

\(^7\) Since in some cases the licensees do not sell the whole amount of seed obtained from EMBRAPA, there are carry-over inventories for the next year; thus, in a given year the licensee can sell more seeds than he or she obtained from EMBRAPA in this particular year (the variable can thus be higher than 100%). Even though the information gathered from EMBRAPA did not allow us to consider the effect of these inventories, we do not believe this is an important problem for the measurement of sale efficiency.
variable allows us to test the proposition that, in a situation of high measurement costs, past experience can provide information about licensees’ capabilities. Namely, a licensee showing low sale efficiency in the past will signal low commercial expertise, thus increasing the probability that EMBRAPA will terminate its contract in the next period. One could also argue that this variable is related to the level of licensees’ commercial knowledge and investments in marketing and sale efforts, in turn related to the level of licensee’s specific investments for this particular licensing program, thus generating the same prediction. In sum, we should expect this variable to be negatively related to contract breach.

- **Productivity**: measures the licensee’s productivity or agricultural yield (total of commercial seeds produced, or multiplied, over the total amount of “basic” seeds obtained from EMBRAPA, in kg). Since it is also a performance variable, we expect Productivity to be negatively related to contract breach, due to the same reasons discussed for Sales Efficiency.

With regard to external disturbances, the discussion in item 4.1 emphasized the possibility of predatory competition as a factor generating high uncertainty over local specific investments by licensees, and hence inducing contract discontinuity. Thus, the level of local market concentration should be relevant in this sense. Two variables are employed to measure concentration:

- **HHR** measures the Herfindahl-Hirschman index of concentration in the region of the licensee based on total amount of seeds acquired from EMBRAPA. A region is defined by the State where the licensee’s headquarters are located, plus adjacent States (since they usually sell in States other than their own). The former discussion implies that this concentration index should be negatively related to contract breach.

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8. It is true that this variable may be also associated with local market conditions (a high demand may induce a high level of sale efficiency due to reasons other than expertise or sale efforts). However, we include controls in the estimation process in order to handle this problem, as detailed later.

9. In some cases, the licensee does not multiply the seeds by himself or herself (vertical integration), but contract some growers to do this process. However, in any case, in order to achieve a high yield the licensee should master techniques associated with proper multiplication of the hybrid.

10. Notice that, if this proposition is correct, we should expect a high market concentration to be related to low likelihood of contract breach regardless of the size, or market share, of the licensee.

11. If $x_i$ represents the share of licensee $i$ in the acquisition of EMBRAPA’s seeds in a given region $j$ with $k$ licensees, then $HHR_j = x_{i1}^2 + x_{i2}^2 + \ldots + x_{ik}^2$. 
• Competitors measures the number of licensees competing in the same region. It is a less precise proxy for concentration than HHR, since it assumes that market shares are equally distributed among licensees, but can provide extra information regarding the intensity of strategic interaction and complexity in a given region. This variable should be positively related to contract breach.

Finally, regarding contractual governance, we employ the following variables:

• Multiple contracts: it is a dummy variable coded one if the licensee has multiple licensing contracts with EMBRAPA. Some licensees have also contracts for hybrids other than the BR-201 (namely, BR-205 and BR-206, not included in the sample). We expect that the existence of multiple contracts reduce contract breach since EMBRAPA can make use of “bundles of safeguards” (de Figueiredo and Teece, 1996) against behavioral hazards by licensees.

• Incentive measures the incentive alignment of the transaction. Every year, EMBRAPA collects royalties from the licensees based on the unit price of the seed sold to growers (a variable called Price), the licensee’s productivity (measured by Productivity) and the performance of sales (Sale efficiency). For each year, we regressed the actual royalties against Price, Productivity, and Sales Efficiency, and generated predicted values of royalties\textsuperscript{12}; these values are thus what a given licensee should expect given the “average” compensation of his or her peers. Incentive is the difference between the predicted and the actual royalties (i.e., the negative value of the residual in the former regression). It is indeed a measure of incentive alignment because a licensee who is, for instance, “overcharged” (negative Incentive) is more likely to breach the contract. Conversely, EMBRAPA may compensate good licensees with lower royalties in order to keep them in the program, or penalize others (low Incentive) in order to force them to leave. Therefore, we predict that the higher the incentive alignment, the lower is the likelihood of breach.

Control variables were also used in alternative specifications of the model:

\textsuperscript{12} The fit of these regressions was very high (ranging from 0.82 to 0.98), with all variables significant at conventional levels.
• **Price**: as defined before, it is the unit price of the seed sold to growers. This variable is included in order to control for types of breach caused by default or adversarial market conditions (e.g., low prices) for reasons other than those articulated in our propositions.

• **Y91, Y92, …, Y96** are dummy variables for each year, in order to control for time-effects such as a particular seasons inducing systemic bad market conditions, or some “maturation” of the licensing program over time.

The possible problem of endogeneity between duration and the explanatory variables (Petersen, 1993, p. 471) is not a relevant issue here since all variables are measured in the year prior to the year when continuity or breach of the contract is observed; thus, all explanatory variables are “naturally” lagged.

### 4.5. Results and Discussion

Tables 1 and 2 report respectively descriptive statistics and correlations of the variables used in this study. (*Duration* measures the duration of the licensing contract, and is used as the duration variable in the Cox model.) An inspection of the correlation matrix reveals no possible problems of multicollinearity.

<*** Tables 1 and 2 around here ***>

The model was estimated by maximum-likelihood, with robust calculation of the correspondent variance-covariance matrix (Lin and Wei, 1989) considering the nature of the data, which requires “clustering” of observations according to each contract (licensee). Table 3 presents the estimated coefficients of the Cox proportional hazard model for three specifications: (1) without control variables; (2) controlling for *Price*; and (3) controlling for *Price* and the year dummies (Y92, …, Y96). Given the nature of the alternative hypotheses (specifying a specific sign of the coefficients), test are one-tailed.

<*** Table 3 around here ***>

Results are fairly similar across the alternative specifications, but the inclusion of control variables (especially the year dummies) improve the explanatory power of the model. All coefficients are with predicted signs, except *Productivity*, but this variable is non-significant at conventional levels. However, the other performance variable, *Sale efficiency*, is significant at a 5% level in the model with all controls (3) and with expected
sign, supporting the hypothesis that a high commercial performance reduces the likelihood of contract breach in the next period. The hypothesis that licensees who obtain larger amounts of seeds from EMBRAPA (measured by *Quantity*) are associated with longer contract duration is supported with 5% of significance.

Support is also found for variables related to governance, especially incentives. Licensees who are “overcharged” (low *Incentive*, or a level of royalty higher than what they would expect given their performance) are associated with a higher hazard of contract breach with a 1% level of significance. The hypothesis that licensees with hybrids other than the BR-201 (*Multiple contracts* = 1) are associated with longer contract duration is supported with a 5% level of significance.

Weaker support is obtained for variables related to external disturbances. Number of *Competitors* in a given region, although with expected sign, is not significant. The concentration index *HHR*, however, is significant with a 10% level in the model with all controls (3). This, the proposition that a higher concentration of multipliers of the BR-201 hybrid in a given licensee’s region reduces the likelihood of contract breach, possible due to a lower level of predatory competition, is moderately supported. The non-significance of *Competitors* may mean that it is not important how many licensees are competing in a region, but if few licensees dominate the production and hence help to “discipline” the market against predatory practices.

### 5. CONCLUSIONS

A distinctive feature of this study is an analysis of contract duration on an *ex post* basis, rather than the usual focus on duration or length as a contractual clause defined *ex ante*. This provides a more dynamic specification of contractual arrangements, crucial to our understanding of the mechanisms inducing contractual stability and adaptability. In the context of licensing agreements, four aspects seem crucial to generate stability (i.e., reduce contractual breach): the characteristics of the transaction, the governance

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13 This result is not an artifact from our construction of *Incentives*. An alternative specification to calculate predicted royalties, based on the multiplicative term *Price* *Sale efficiency* *Productivity* (which is reasonable since this term is related to licensees’ revenues per kg of seed obtained from EMBRAPA) generated similar results.
mechanisms (incentives and controls) devised to support (autonomous and induced) adaptation, the impact of external disturbances, and the protection of intellectual property rights. This theoretical analysis framework in general received empirical support when applied to plant genetics licensing contracts in the Brazilian seed industry.

The generalization of the findings are limited due to the specific nature of the problem under analysis and the restricted sample, but the results leave room for similar studies in other industries and contexts. One promising area of investigation is the impact of contract stability on firm’s performance. Even though less frequent contract breaches reduce transaction costs, they can at the same time reduce firm’s flexibility to find out new partners or develop new types of capabilities. In any case, a focus on the evolution of formal and informal contract clauses is likely to generate better insights than the usual preoccupation with *ex ante* terms.
REFERENCES


**Figure 1**
The Seed Supply Chain

**Table 1**
Descriptive Statistics ($N = 141$)

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<tr>
<th>Variable</th>
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<th>Std. Deviation</th>
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<td>Productivity</td>
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Table 2
Correlation Matrix ($N = 141$)

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Table 3
Cox Proportional Hazard Models for Contract Duration: Maximum Likelihood Estimates
(Robust Standard Errors) ($N = 141$)

<table>
<thead>
<tr>
<th>Variable</th>
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<th>(1) Controlling for Price</th>
<th>(2) Controlling for Price and Year</th>
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<td>-0.0002**</td>
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<tr>
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<td>(.0006)</td>
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<tr>
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<td>31.65*</td>
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<td>Pseudo $R^2$</td>
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</table>

Levels of significance: * 1% ** 5% *** 10% (one-tailed tests, except $\chi^2$).