# Reputation and the Dynamics of Contractual Incompleteness[☆]

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**Abstract**

This article examines why in some cases parties are willing to sign agreements that are left intentionally incomplete with regard to future contingencies, and why they prefer to choose more complete agreements in other situations. More complete contracts allow the avoidance of ex-post renegotiations and the risk of hold-up, but also mean that parties have to expend more costs on ex-ante design. Another way to avoid ex-post hold-up is to rely on relational contracting: One of the partners promises to renew the contract if the other does not hold up in the case of renegotiations. This allows savings on ex-ante costs, and by implication, leaving the contract incomplete, but respect of the informal agreement is more uncertain. We build a model to show how parties to a contract choose between these two solutions to avoid hold-up, and how the degree of contractual (in)completeness evolves over time.

*Keywords:* Contractual Dynamics, Contractual Incompleteness, Reputation, Relational Contracts.
*JEL:* D23, L14, L24

## 1. Introduction

In mainstream theory, writing contracts is cost free, and agents can foresee all the future state of the world. However, business practice shows that it is not possible to predict all future contingencies, and unforeseen events arise that force parties to renegotiate their contractual agreements. Many theoretical and empirical works have progressively assumed contractual incompleteness (Williamson, 1975, 1985; Klein et al., 1978; Joskow, 1987; Grossman and Hart, 1986; Hart, 1995), and explored the consequences of it on renegotiations, hold-up, or vertical integration. Yet, in spite of its potential deleterious effects, contractual incompleteness does not hinder trade

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or cooperation (Crocker and Reynolds, 1993). Recent advances on contract theories offer a partial explanation for this surprising observation. They emphasize the role relational contracting plays in circumventing difficulties in formal contracting (Bull, 1987; Macaulay, 1963; Baker, Gibbons and Murphy, 2002; Gibbons, 2005). Relational contracts are informal agreements sustained by the value of future relationships. They facilitate outcomes that could not otherwise be achieved through incomplete formal contracts.

However, while the problems raised by contractual incompleteness and their possible solutions have been well identified, the causes of incompleteness *per se* have attracted far less attention. Following the bounded rationality approach of Simon (1951), Williamson (1975) argues that gathering and processing information is costly. This explains the use of heuristics in contract design. Grossman and Hart (1986), Hart and Moore (1990), Hart (1995) reject bounded rationality but they assume that parties are unable to write a contract with a long list of details covering every eventuality in such a manner that a court can enforce it. Contracts therefore remain incomplete, even if parties can figure out the utility consequences of each situation. In all these works, the standard assumption is one of exogenously, and immutably, imposed contractual incompleteness. On the other hand, Crocker and Reynolds (1993) show empirical evidence that agents are given incentives to enter agreements that are intentionally left incomplete. In our paper, we propose a theoretical model to explain why parties voluntarily agree to sign incomplete contracts. Our main point is to show that contracts are left incomplete, when parties know that the relational contract avoiding hold-up is sustainable. Then, the causality between relational contracting and contractual incompleteness can run in both directions: relational contracting is not only a response to contractual incompleteness, but also generates it. Yet, when parties anticipate that a relational contract is unsustainable, they prefer to sign a complete contract.

To reach this goal, we adopt an incomplete contract perspective, with the introduction of ex-ante costs allowing parties to learn about future contingencies. More precisely, the model considers a buyer and a seller engaged in an infinitely repeated game with incomplete information. The parties initially contract on an available design, perhaps an industry standard, the best under existing knowledge. However, parties are aware that not all contingencies are foreseen. As a consequence, the parties may realize that the contractual design is inappropriate during its execution. In this paper, we take an incomplete contract to mean a contract whose design turns out to be inappropriate, and needs to be renegotiated.

Before signing, the buyer may exert some cost (effort) to find out what could go wrong and how to draft the contract accordingly, to reduce the incompleteness of the contract. He can do this because a contingency is foreseeable (perhaps at a prohibitively high cost), but not necessarily foreseen. It is more likely to be foreseen if some ex-ante efforts are made to learn about future states of the world.

In our model, the buyer decides the level of ex-ante contracting costs (at the first stage of each period) and the renewal (or not) of the contract (at the last stage of each period). As for the seller, he decides to hold up or not in case of renegotiation due to contractual incompleteness. The buyer's goal is to avoid renegotiations with hold-up, and he has two strategies to achieve it. One is that he can decide to in-

vest in a lot of ex-ante information gathering, and aim to have as near complete a contract as possible. This is a costly option, but allows parties to reduce the risk of incompleteness significantly and, by implication, reduce the risk of renegotiation. A second solution is voluntarily to sign an incomplete agreement, and to rely on relational dealing with the seller. In an informal agreement, the buyer promises the seller a high probability of renewal. In exchange, the seller informally commits to avoid hold-up if renegotiation is needed. This solution allows savings on ex-ante contracting costs but is uncertain, because the seller may renege on the informal promise, and decide to hold up, even though he will lose the higher probability of renewal. Our results show that when trust is built over time, parties choose the first strategy at the beginning of a relationship, and subsequently turn to the second (relational contracting). As a consequence, contracts become more and more incomplete and relational as times goes by. But if parties are unreliable, they prefer to take on ex-ante contracting costs and have a complete contract.

To sum up, the originality of our contribution is to show that contractual incompleteness is a deliberate choice and evolves over time, as parties to a contract learn more about each other. We emphasize relational contracting as a factor to explain contractual incompleteness: because parties rely on relational contract to avoid hold-up, they save on ex-ante contracting costs and have a less complete (formal) contract. With this result, we depart from the traditional view of relational contracts, which are considered only as an answer to contractual incompleteness.

The paper is organized as follows. In the next section we review previous literature and show how our contribution relates to it. In section 3 we describe the framework of our model, introducing a buyer/seller model in an incomplete contract framework. The buyer may support some ex-ante contracting costs to learn about future contingencies, and influences the degree of contractual (in)completeness. Section 4 describes the two strategies to avoid hold-up: the buyer can either spend more ex-ante, or he can propose relational contracting, which is less expensive but more uncertain. In section 5 we determine the trade-off between the two strategies. We introduce two types of partner, i.e. those who respect informal commitments, and those who may deviate. We show how a learning process allows buyers to determine the profile of their partners, i.e. their reputation for reliability, and to implement relational contracts with trustworthy co-contractors. The results of our model show that when partners economize on the ex-ante contracting costs of "additional completeness" and rely on informal dealings with trustworthy partners, it leads to increase the degree of contractual incompleteness. Section 6 concludes and calls for an empirical investigation of our results.

## 2. Related Literature

This paper builds on and contributes to two strands of the contract literature: incomplete contract theory and relational contract theory. The idea of contractual incompleteness dates back to the earlier development of the transactions cost literature (Williamson, 1975, 1985) and the property-rights literature (Grossman and Hart, 1986; Hart and Moore, 1990). Many subsequent works explored the notion of contractual incompleteness, sometimes leading to conflicting results (MacLeod,

2000). Transaction cost theory assumes bounded rationality to explain contractual incompleteness, but does not formalize it. The literature on property rights assumes that agents cannot describe all future contingencies ex-ante, but can rationally anticipate their effects. It considers trade as contractible ex-post, but not ex-ante. Thus, the parties have to leave outcomes open to future renegotiation. This compromises their incentives to undertake ex-ante relationship-specific investments, since the outcome of the renegotiation results from the parties' bargaining positions in the ex-post renegotiation. This is determined by the allocation of property rights over the assets. However, since its emergence, incomplete contract theory has been attacked for its failure to provide a rigorous foundation for contractual incompleteness. The theory does not explore the consequences of unforeseen contingencies, instead, it is concerned with indescribable contingencies (Maskin and Tirole, 1999). This calls for further study of the emergence of contractual incompleteness.
As underlined by MacLeod (2000), a growing literature demonstrates that contracting parties choose to write incomplete contracts in many situations. For instance, when there are costs for including contract terms, Shavell (1984) argues that for low-probability events, it is cheaper to let the courts fill the gaps. Battigalli and Maggi (2008) propose a principal-agent model where writing formal contracts is costly and consider both formal and informal contracts. Formal contracts can be contingent, that is, detailed agreements recognizing numerous contingencies; or spot, that is, contracts that are revised as contingencies arise. Their results show how the level of writing costs, the uncertainty, and the durability of the relationship determine the choice between spot and contingent contracts. They then explore the conditions under which it is optimal to combine formal and informal contracting, and how the level of writing costs determines the optimal mix of both. Our paper departs from their work by exploring the reverse mechanism: how the trust base of informal agreements allows savings in writing costs and the degree of formal completeness.

Our paper is also related to the empirical works of Crocker and Reynolds (1993) and Banerjee and Duflo (2000). In their paper, Crocker and Reynolds show that the level of contractual incompleteness is endogenously determined by the complexity of the environment, because complexity will increase costs of contracting and temptations for opportunistic behaviors.[1] There is then a trade-off between the cost of writing formal contracts and the benefits of avoiding opportunistic behaviors. The authors test their proposition on panel data on the pricing procedures used in Air Force engine procurement contracts. Their results prove that the degree of contractual incompleteness reflects the parties' desire to minimize the economic cost of a contractual exchange. However, while Crocker and Reynolds examine how the complexity of the environment determines the level of contracting costs, we adopt a somewhat different perspective by introducing dynamics and showing how the implementation of a relational contract also influences the level of contracting costs. In their contribution, Banerjee and Duflo assess quantitatively the importance of reputation and, by implication, the seriousness of the limits on contracting, using data

[1] In some other papers (as in Crocker and Reynolds (1993)), contracts are said to be "incomplete" or "complex". Both words are interchangeable: complete contracts may be complex, and the inability to implement complex agreements leads to contractual incompleteness.

from the Indian customized software industry. They show that parties' reputations influence the chosen contract (fixed-price contract versus time and materials contract) and contractual outcomes (sharing of cost overruns). Their theoretical results and empirical evidences argue that reputation (measured through the age of the firm, its ISO certification and its past experience with clients) favors time and materials contracts and more equitable sharing of costs overruns. This result is consistent with the idea that repeated interactions could lead to less complete contracts and more contingencies left to ex-post adaptation. Our paper is close to theirs, but we enrich their approach by considering that clients periodically revised their perception of the firm's reputation. As a consequence, contractual (in)completeness evolves over time. More recently, Tirole (2009) and Bolton and Faure-Grimaud (2007) have also built theoretical models where writing formal contracts is costly. Tirole develops a model of limited cognition and examines its consequences for contractual design. He shows that contracts are predicted to be strictly less complete under relational contracting or vertical integration. Our model complements this view, and allows us to show how the degree of contractual incompleteness depends on growing trust between parties, which has not previously been analyzed in the literature.

Our paper also builds on the relational contract theory. The traditional literature on relational contract theory investigates the emergence of informal contracting when formal contracting may yield to suboptimal outcomes (Macaulay, 1963; Bull, 1987; Baker et al., 1994, 2002, 2008). For example, these contracts arise when the number of contingencies is so large that it is not possible to write a complete contingent contract, creating problems for the interpretation and enforcement of contract terms and conditions (MacLeod, 2000). The main idea sustaining such contributions is that parties are willing to commit themselves informally on some actions, when the discounted payoff stream from cooperation is higher than the discounted payoff stream from deviation. Because these agreements are tacit, they cannot be enforced by third parties and have to become self-enforcing, hence the proposition that the value of the relationship must be sufficiently large so that neither party wishes to renege. Nevertheless, these works assume symmetric information between parties: they know perfectly whether their partner will have an interest in cooperating or in deviating from its tacit commitment. This means that there is no doubt about the (un)sustainability of the relational contract. We depart from this view by assuming that parties do not know whether or not the informal agreement is sustainable for the co-contractor, that is, they do not know their partners' level of reliability. However, they may guess it through a learning process. The more transactions they have together, the more able they are to learn. As trust grows up over time, parties are more willing to rely on relational contracts that allow saving on ex-ante contracting costs. These costs aim to elaborate as complete a contract as possible, which is why the contract becomes more incomplete if fewer costs are spent.

To reach this goal, our model takes inspiration from Tirole's framework (Tirole, 2009), and exploits one of the intutions it raises, namely how relational contracts can generate contractual incompleteness by enabling parties to pay fewer ex-ante contracting costs.

## 3. The theoretical framework

### *3.1. Agents*

Let us consider two agents: a buyer (B, whom we refer as "he") and a seller (S, whom we refer as "she").
We suppose that contracts[2] between B and S are renewed periodically. We denote each contractual period t, t+1, t+2,... t+n.

### *3.2. Contract design*

At the beginning of each period, the buyer and the seller agree on a contractual design, denoted as design A. This design refers to the formal contract they sign, i.e. the formal agreement where they define rules, mutual obligations, and reciprocal commitments. We adopt an incomplete contract perspective[3] (Grossman and Hart, 1986; Hart, 1995; Tirole, 2009): parties are unable to foresee each future contingency ex-ante, when they sign the contract. As a consequence, the contractual design may be inappropriate during the execution of the contract, and need to be altered. In this paper, an incomplete contract is a contract whose design turns out to be inappropriate, and is renegotiated.
More precisely:

- **With probability** $1-\rho$, design A is the appropriate design. Then, the contract is "complete", because there is no need to change the terms of the contract, and to renegotiate: eveything happens as foreseen ex-ante. The contract delivers utility $K^+$ for B and costs the seller c to produce ($K^+ > c > 0$).[4] As a consequence, the utility of the buyer is $U_B = K^+ - P0$, where $P0$ denotes the ex-ante bargaining price.[5] As for the seller, her payoff is $U_S = P0 - c$.

- But, **with probability** $\rho$, design A is inappropriate and only delivers $K^-$, with $K^- = K^+ - \Delta$ where $\Delta > 0$. Then, the contract is incomplete and parties need to renegotiate their agreement. Indeed, some other, initially unknown, design $A'$ delivers utility $K^+$ to B. Converting A into $A'$ implies contract's modifications, that cost "a" to B, with a $\in [0; \Delta[$. This parameter "a" can be

[2]The motivation for long-term contracting as an alternative to hierarchy and/or spot market exchange has been examined theoretically (Williamson, 1979, 1985; Klein et al., 1978) and empirically (Joskow, 1987; Crocker and Masten, 1988). In this paper, we do not consider the tradeoff between hierarchies, spot market and long-term contracting. We assume straightaway that the contract is the preferred mode of exchange, and our concern is with the degree of contractual completeness the parties select.

[3]As for Tirole (2009, pg. 265), "the parties to a contract (buyer, seller) initially avail themselves of an available design, perhaps an industry standard. This design or contract is the best contract under existing knowledge. The parties however are unaware of the contract's implications, but they realize that something may go wrong with this contract".

[4]This cost $c$ is the production cost of the seller, and not a contracting cost. The contracting costs (described in subsection 3.3) are supported by the buyer.

[5]Such a price reflects the ex-ante bargaining power of the parties. For simplicity, $P0$ is here exogenous, but we could derive it endogegnously using Nash Bargaining, and assuming a level of bargaining power for each partner. This would not change our results.

assimilated to some ex-post transaction costs supported by the buyer. Then, net gains from renegotiations are $\Delta - a$.[6] The seller's opportunism is the primary concern in this paper, as it is in most of the contracting literature (Crocker and Reynolds, 1993). Consequently, the seller can decide to hold-up the buyer during the renegotiation process, i.e. she grabs a part $h(\in]0; \Delta - a])$ of the net gains of renegotiation.
At this stage of the game, we assume that the seller holds up the buyer in case of renegotiation, with some probability $x \in [0; 1]$.[7]
As a consequence, when the design is inappropriate:

- If the seller chooses to hold-up B (with some probability $x$), the utility of the buyer is $U_B^H = K^+ - P0 - a - h$ and her utility is $U_S^H = P0 - c + h$.
- If the seller does not hold-up B (with some probability $(1-x)$), the utility of the buyer is $U_B^{NH} = K^+ - P0 - a$ and her utility is $U_S^{NH} = P0 - c = U_S$.

The initial framework of our model is summarized in Figure 1.

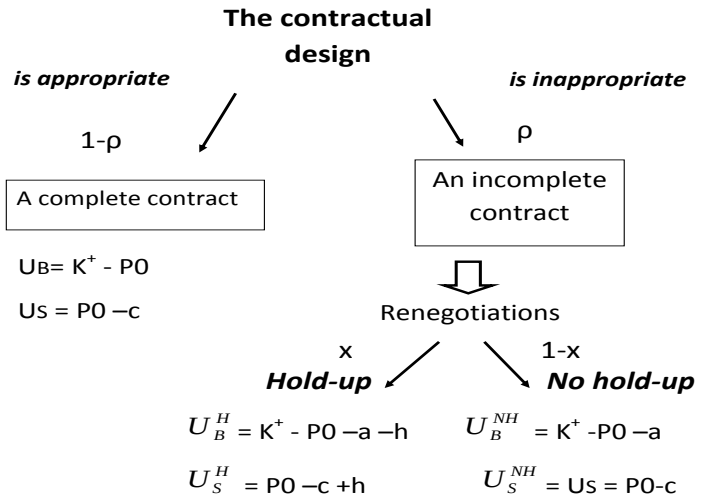



Figure 1: The initial distribution of payoffs

From Figure 1, we can observe that the worst situation for the buyer is that of renegotiation with hold-up. The buyer's goal will be to avoid such a situation. To prevent this opportunism, the buyer may want to sign a well-detailed (complete) contract, but this is a costly strategy. We will now show how the buyer decides the degree of contractual completeness, that is, how much he spends in ex-ante contracting costs.

[6] We assume that trade is efficient, i.e. $K^+ - c - \rho a > 0$.

[7] We detail the determinants of $x \in [0; 1]$ in subsection 4.2. At this stage of the game, we assume that $x$ is an exogenous parameter, and we endogenize it in subsection 4.2.

*3.3. Degree of contractual completeness*

In our model, following the previous literature on this topic (Crocker and Reynolds, 1993; Battigalli and Maggi, 2008; Tirole, 2009), the degree of contractual completeness is related to the ex-ante costs of contracting. More precisely, B can influence the probabilities described in subsection 2.2 $(\rho; 1-\rho)$ by performing actions to learn about future contingencies, and then proposing a more or less complete contract. We then assume that, before contracting, B can incur some costs to foresee future contingencies better. Those costs have a broad range of interpretations: for Dye (1985), they refer to the costs of writing contracts (*ink costs*), while Klein (2000) mentions the costs of thinking through the implications of contracts (*search costs*). Tirole (2009) considers cognitive costs thinking about contingencies, designing covenants and seeing through their implications.[8] In all of these cases, the costs incurred before signature of the contract determine the level of (in)completeness. Consequently, in this paper, we will use the expression "costs of additional completeness" (or "ex-ante contracting costs") to stress the idea that degree of completeness is an increasing function of the amount of the costs spent before the signature of the contract. Indeed, these costs allow parties to determine ex-ante what may go wrong and to draft the contract accordingly. We denote them as $T_B(k)$, where $k(\in [0;1[)$ represents the intensity of the effort to learn about future contingencies. The function $T_B$ is smooth, increasing, and convex, so that $T_B(0) = 0$, $T'_B(0) = 0$, and $T_B(1) = +\infty$[9] for every possibility. It means that, by incurring more costs of additional completeness, B may increase his chance of discovering the appropriate contractual design, that is, to propose a more complete contract.[10]

We assume that if A is the appropriate design, B learns nothing from his investigation (noticeably because there was nothing to learn). Yet, if $A'$ is the appropriate design, B learns $A'$ with probability $k$, and learns nothing with probability $1-k$. This means that $k$ is both the intensity of effort to learn about future contingencies and the probability of finding that design A is inappropriate, if it is indeed the case. As a consequence, if the buyer supports some ex-ante costs of additional completeness, this action changes the probability of the contractual design defined ex-ante being appropriate or not. The contract is appropriate (complete) with a probability $(1-\rho)+\rho\times k$[11], while the contract is inappropriate (incomplete) with a probability $\rho(1-k)$. The implication of the ex-ante contracting costs on contractual

[8] These costs include managers' psychic costs of focusing on issues they are unfamiliar with, opportunity costs of time taken from other important activities, and fees paid to lawyers and consultants for advice on contracting.

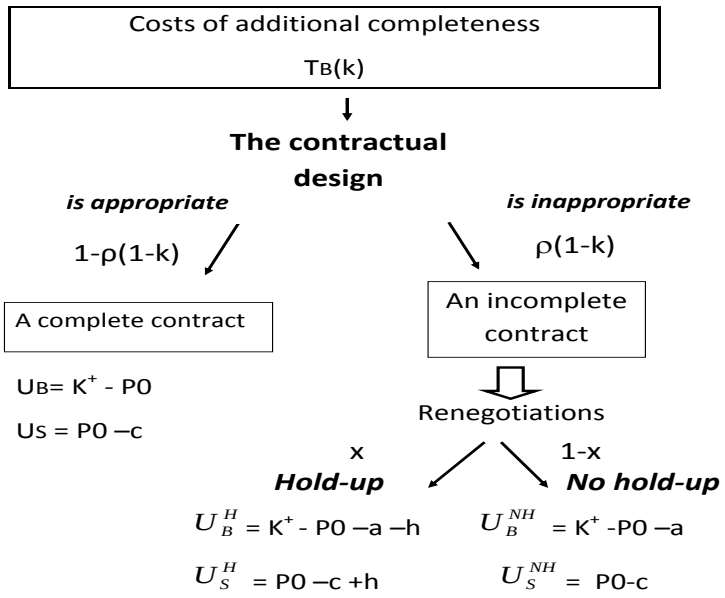
[9] $T_B(1) = +\infty$ suggests that costs of thinking about a complete state-contingent contract would be astronomical. We consider that it is simply impossible to create a contingency plan. This point was made earlier by Williamson (1975).

[10] As Tirole (2009, pg. 265) puts it, "a contingency is foreseeable (perhaps at a prohibitively high cost), but not necessarily foreseen. To take a trivial example, the event that the oil price may increase, implying that the contract should be indexed on it, is perfectly foreseeable, but this does not imply that parties will think about this possibility and index the contract price accordingly"'.

[11] $(1-\rho)$ represents the probability that A is appropriate but B is unaware of it, as he learns nothing from his investigation; and $\rho \times k$ is the probability that A is inappropriate, but because of his ex-ante costs, B becomes aware of it and is able to propose $A'$ before the contract is signed. Moreover, we note that $(1-\rho)+\rho\times k = 1-\rho(1-k)$.

completeness can be illustrated by modifying Figure 1, as shown in Figure 2.

Figure 2: Contingencies with costs of additional completeness

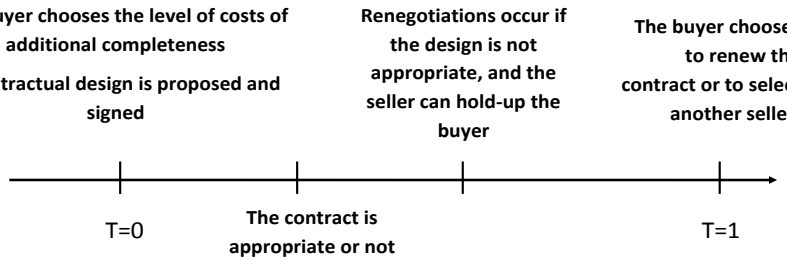



Hence, in accordance with Tirole (2009), the fewer the costs $T_B(k)$ spent to identify the appropriate design, the more incomplete a contract will be; and the higher the probability that the design specified in the contract will need to be altered ex post. Symmetrically, the greater the cost of spending on additional completeness before signing, the more complete the contract will be.[12] The interesting feature of our model is that the choice of costs of additional completeness will depend on the parties' willingness to leave the contract intentionally less complete. In practice, this choice can be measured by how explicitly parties want their future duties and contingencies to be enumerated in the formal contract. As an illustration, Crocker and Reynolds (1993) give the example of different contract types in defense procurement. They propose an ordered typology of contract according to how the price is determined. The most restrictive and complete contract is the "firm-fixed price" contract in which price is specified ex-ante. A more flexible option (but at the cost of potentially uncovered contingencies) is the "fixed-price incentive successive targets" contract where there are periodic renegotiations of nonbinding target process: targets for cost, profit and price are defined ex ante, but final cost, profit and price are defined ex post.

Returning to our model, the timing of the game is shown in Figure 3.

[12]Let us add that the enunciation of $A'$ by B fully reveals to S that the proper design is $A'$. The choice of $T_B$ is rational, and not observed by S.

Figure 3: Timing of the game for one contractual period




## 4. Two solutions to avoid renegotiations with hold-up

The goal of the buyer is to avoid renegotiations with hold-up. He has two strategies to reach this goal. On the one hand, he can try to avoid renegotiations (the risk of hold-up automatically decreases with the risk of renegotiation). On the other, he can try to minimize hold-up but not renegotiations. Thus, he faces a tradeoff between the ex-ante costs of crafting more complete agreements and the potential ex-post inefficiencies associated with less exhaustive, but less costly, agreements. More precisely:

- Either the buyer spends a lot on additional completeness to have as complete a contract as complete as possible. This strategy aims to avoid incomplete contracts, which lead to renegotiations and the risk of hold-up.
- Or the buyer accepts an incomplete contract and relies on the seller's ability to respect the spirit of the contract, that is, not to hold up if a renegotiation occurs. In subsection 4.2. we show why this is a relational contracting strategy.

As a result, this tradeoff explains the endogenous choice of the degree of contractual completeness and why agents may be willing to enter agreements that are left intentionally incomplete with regards to future contingencies. In the following subsection, we explore in more details these two strategies: the increase of formal completeness (section 4.1), and the relational contracting (section 4.2).

### *4.1. Strategy 1 to avoid hold-up: Increasing the formal completeness of the contract*

Let us determine the optimal level of ex-ante costs aimed at foreseeing future contingencies, $T_B(k)$. When the buyer wants to foresee future contingencies better, he supports more costs $T_B(k)$, and diminishes the probability that the contract will become inappropriate. As we stated in the previous section, the choice of the amount of costs $T_B(k)$ will depend on the buyer's maximization of expected payoffs in each situation:

$$\max_k -T_B(k) + \rho(1-k)U'_B + (1-\rho(1-k))U_B \tag{1}$$

where $U'_B$ is the buyer's expected payoff when the contract is incomplete ($U'_B = xU_B^H + (1-x)U_B^{NH}$), and $U_B$ is his payoff when the contractual design is appropriate, and there is no need to renegotiate ($U_B = K^+ - P0$). From figure 2, we can write (1) as:

$$\max_k -T_B(k) + \rho(1-k)(K^+ - a - xh - P0)) + (1 - \rho(1-k))(K^+ - P0) \qquad (2)$$

Differentiating (1), we obtain:

$$\max_k -T'_B(k) - \rho(K^+ - a - xh - P0) + \rho(K^+ - P0) = 0$$

$$T_B^{'}(k) = \rho[a + xh] \qquad (3)$$

Using some comparative statics, and knowing that $x, a, h, \rho \geq 0$, we can deduce from (3) some results about ex-ante costs of additional completeness $T_B(k)$. Since $\frac{\partial T_B^{'}(k)}{\partial a} da = \rho \geq 0$, $\frac{\partial T_B^{'}(k)}{\partial x} dx = \rho h \geq 0$, $\frac{\partial T_B^{'}(k)}{\partial h} dh = \rho x \geq 0$, then the level of the costs of additional completeness increase with the parameters $a, x$ and $\rho$.

**Proposition 1.** *When the ex-post adjustment costs (a), the level of potential hold-up (h) and the probability of hold-up in case of inappropriate contractual design (x) increase, the buyer spends more costs of additional completeness $T_B(k)$ and the contract becomes more complete.*

**Corollary of proposition 1**. *If the seller is willing not to hold-up during renegotiations ($x \to 0$), fewer costs $T_B(k)$ are incurred by the buyer and contracts become more incomplete.*

This kind of proposition is consistent with the empirical results of Crocker and Reynolds (1993) who showed that the sellers' willingness to engage in adversarial proceedings (i.e. her willingness to hold up) increases the marginal benefits the buyer will obtain by crafting a more complete agreements (since $\frac{\partial T_B^{'}(k)}{\partial h} dh = \rho x \geq 0$).

To conclude, it seems that:

- The buyer can avoid the risk of hold-up, by spending on ex-ante costs of additional completeness. These costs allow him to learn about future contingencies, and to propose a more complete contract. If renegotiations are avoided, the risk of hold-up will decrease.

- However, even if this solution avoids hold-up, it is a costly strategy, since the buyer has to support the cost $T_B(k)$. There is then a trade-off between the costs of additional completeness $T_B(k)$ and the gains from the reduction of hold-up. This allows us to define an optimal level of costs of additional completeness, as shown in equation (3).

In the next section we explore an alternative to this strategy. Instead of supporting ex-ante contracting costs to make the contract more complete, the buyer

can propose a relational contract, to prevent the seller from holding-up. This strategy would allow saving on ex-ante costs of additional completeness, while avoiding hold-up in case of renegotiations.[13]

*4.2. Strategy 2 to avoid hold-up: Relational contracting*

*4.2.1. The relational contract*

When the agents are in a long term relationship and care about reputation, some positive consequences on their behavior can be expected. For instance, Baker et al. (2002, 2008) show that some incentives to invest can be generated by concern for future relationships, and Bull (1987) and Klein (1988) suggest that reputation effects can limit hold-up problems.

In our model, we also show how future business may avoid renegotiations with hold-up. Indeed, the buyer can choose to sign an incomplete formal agreement, which allows him to economize on ex-ante costs $T_B(k)$, and try to convince the seller not to hold up if renegotiations occur. We assume that this proposition is based on a relational contract, that is, an informal dealing between the parties sustained by the value of the future relationship. As previously said, the buyer can choose, at any stage, to pursue or to end the relationship. As a consequence, if S does not respect her commitment, B threatens to renew her in the future with a lower probability. Indeed, in the model, we suppose that contracts between B and S are renewed periodically. It is important to note that in any period, the buyer may decide to choose another seller or to keep the same one. As the buyer has the possibility of rewarding cooperative behavior by renewing the contract with the same seller, or to punish uncooperative behavior by switching to another partner, contract renewal can act as an incentive for the seller to behave honestly. For the sake of simplicity, we assume that reputation is built in a bilateral relationship, and there is no outside option for the seller who deviates from it.[14]

Then, we use the trigger strategy framework, with Nash reversion to static equilibrium in case of deviation to account for such a situation. In our framework, a period is considered to be the duration of a contract. As a consequence, at each period, the buyer can choose to pursue or to end the relationship. The discount factor is denoted $0 \leq \delta \leq 1$. Following the traditional literature on relational contracting (Bull, 1987; Baker et al., 1994, 2002; MacLeod, 2000), the seller respects her informal dealing, whenever the payoff stream from cooperation is higher than the payoff stream from deviation. This is the condition by which relational contracts become self-enforced.

When the contractual design is inappropriate and needs to be filled, the seller has to choose her strategy. More precisely, she faces the following alternatives:

[13]This strategy does not prevent renegotiations, only hold-ups. Yet, it may be more profitable for the buyer to save on ex-ante costs and to support some ex-post costs $a$ in case of contractual inappropriateness, than to have a costly formal complete contract.

[14]The respect or deviation of S has some consequences on the probability of being renewed by B but we cannot determine the consequences for future business, with other potential buyers. This would require knowing whether the communication between all the buyers on the market is perfect or imperfect. If we assume perfect communication between all buyers who agree to apply the same sanction to a deviating partner, this would prevent all kinds of opportunism, and justify why the outside option is zero. Such collective punishments are to be found in Greif (1993).

- **Cooperation:** S decides to abide by the spirit of the contract and respects her informal commitment. If the seller accepts the relational contracting, she gains $U_S = P0 - c$. In exchange, she is renewed with probability $p_h \in ]0;1]$. As a consequence, whether the design is inappropriate or not, the gains of the seller are $U_S$[15] , as she adjusts without holding up. We assume that the effects of reputation last forever so that at each future period, the expected gain is $p_h U_S$. Then, her future payoff is $p_h U_S$, and her discounted payoff stream is $U_S + \delta(p_h U_S) + \delta^2(p_h U_S) + \delta^3(p_h U_S) + .....$

- **Deviation:** S deviates and does not respect her informal commitment. She holds up B, whenever possible and then, has a total gain of $U'_S = P0 - c + h$ when she deviates. Since S levies an amount $h$ from B, at next contract renewals, the probability of her being chosen again is $p_l \in [0; 1[$ with $p_l \leq p_h$. In the subsequent periods, B no longer trusts her, and considers that hold-up will occur whenever possible. After having deviated, the expected payoff of S is denoted $U_S^D = \rho(1-k)U_S^H + (1-\rho(1-k))U_S$, since $U_S^H$ is the seller's payoff when renegotiation with hold-up occurs, and $U_S$ is her utility when there is no need of renegotiation. Her future expected payoff for each future period becomes $p_l U_S^D$, and her discounted payoff stream becomes $U_S^H + \delta(p_l U_S^D) + \delta^2(p_l U_S^D) + \delta^3(p_l U_S^D) + ....$

*4.2.2. Conditions of sustainability*

The best strategy for S will be not to hold up B in case of inappropriate design whenever the discounted gains of cooperation are higher than those of deviation:

$$U_S + \delta(p_h U_S) + \delta^2(p_h U_S) + \delta^3(p_h U_S) + .... >$$

$$U_S^H + \delta(p_l U_S^D) + \delta^2(p_l U_S^D) + \delta^3(p_l U_S^D) + ...$$

$$P0 - c + \frac{\delta p_h(U_S)}{1-\delta} > P0 - c + h + \frac{\delta p_l U_S^D}{1-\delta}$$

$$\frac{\delta(p_h U_S - p_l U_S^D)}{1-\delta} > h$$

If we denote $V = (p_h U_S - p_l U_S^D)$, we obtain the following formulation:

$$\tilde{h} = \frac{\delta V}{1-\delta} > h \tag{4}$$

[15] $U_S = \rho(1-k)U_S + (1-\rho(1-k))U_S$. With probability $\rho(1-k)$, the contractual design is appropriate and the seller receives $U_S$, and with a probability $(1-\rho(1-k))$, the contract is renegotiated, but the seller respects her informal dealing and does not hold up B, which also leads to a payoff equal to $U_S$.

We can interpret equation (4) as the determination of a threshold $\tilde{h}$ for relational contract sustainability, i.e. S agrees to cooperate and not to hold up B if the level of hold up (h) is low enough (inferior to $\tilde{h}$). It is more profitable to refuse the present gain $h$ and to benefit from the higher probability of being renewed in the future. We can interpret V ($= (p_h U_S - p_l U_S^D)$) as the value of future business, since it represents the relative gain not to hold up ($p_h U_S$) compared to the expected gain in case of deviation ($p_l U_S^D$).
Let us now discuss the determinants of $\tilde{h}$.

*4.2.3. The determinants of the decision to hold-up or to cooperate*

From (4), we can observe that two factors determine the sustainability threshold $\tilde{h}$:

- **the level of discount factor $\delta$ of the seller:**

  If $\delta \to 0$, then $\tilde{h} \to 0$. In this case, for any $h > 0$, relational contracting is not sustainable. This situation also means that S is impatient and attributes a low value to future gains.

  If $\delta \to 1$, then $\tilde{h} \to \infty$. In this case, the relational contract is sustainable, even for high levels of hold-up. S is very patient and attributes as much importance to the present as to the future.

- **the value of future business (V) for the seller:**

  The higher such a value is, i.e. $V \to \infty$, the higher $\tilde{h}$ becomes, and the more sustainable relational contracts become. Future business represents too strong an opportunity to deviate. Relational contracting is all the more sustainable as V increases.

  The lower this value is, i.e. $V \to 0$, the less sustainable relational contracting is. Indeed, the amount $h$ of hold-up has to become lower and lower to be smaller than $\tilde{h}$. Prospects of future business with B are not strong enough, and relational contracts are not self-enforced.

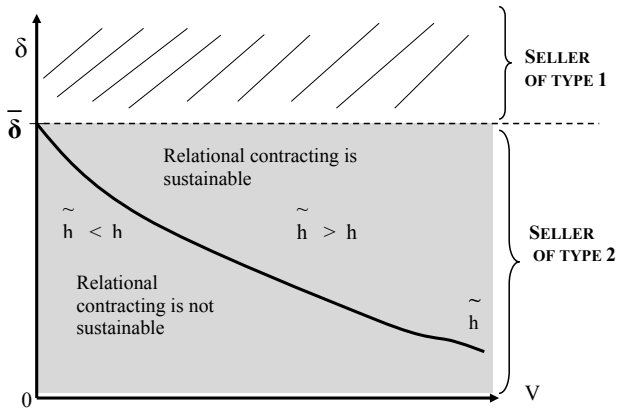
  If $V < 0$, this means $p_h U_S - p_l U_S^D < 0$, that is, the incentives created by the different probabilities of renewal are not strong enough to deter the temptation to deviate from the informal agreement. Relational contracting is not sustainable.

As a consequence, the following proposition can be established:

**Proposition 2.a.** *Both discount factor $\delta$ and relative value of future business $V$ determine the probability that sellers do not hold up buyers in case of inappropriate contractual design, so that $x = x(\delta, V)$.*

Assuming that $V > 0$, such a result may be represented graphically (see Figure (4)).

Figure 4: Sustainable relational contracting as function of $\delta$ and $V$.




- There exists a level $\bar{\delta}$ so that beyond such a level[16], S proves to be very patient, and relational contracting is sustainable, whatever the value V. We denote this seller as "type 1 seller".

- Under $\bar{\delta}$, the cooperation depends on the value of V. The higher V, the more sustainable relational contracts are. The value of future business becomes so high that S had better not hold up to benefit from the more favorable probability $p_h$ of being chosen again in the future. But when $V$ is low, the relational contract is not sustainable. We denote this seller as "type 2 seller".

*4.2.4. Competitive pressure*

Proposition 2.a. introduces the classic results of the literature on relational contract, that is, informal agreements are sustainable depending on the value of future business and the discount rate. However, we can highlight a third factor. Since $V = p_h U_S - p_l U_S^D$, it depends on the value of future business (represented by the value of the expected payoffs), but also on on the competitive pressure that appears through the probabilities $p_h$ and $p_l$. Suppose for instance that our market is oligopolistic, then the competitive pressure is low. There may be no other credible alternative for the buyer than to choose the same seller. The consequence is that $p_l > 0$. The weaker the competitive pressure, the higher $p_l$ is.

To analyze the effect of competitive pressure, let us assume that the buyer always rewards cooperative behaviors, that is, $p_h = 1$, which means that whenever relational contracting is respected, the seller is certain to be chosen again at the next contract renewal. V becomes $V = U_S - p_l U_S^D$

It is now easy to see that whenever $p_l \to 0$, V increases. In other words, V grows when $p_l$ tends to be lower. This implies that the higher the competitive pressure, the higher V, and the more easily relational contracts are enforced.This is consistent with

[16]From (4), we can determine this level $\bar{\delta}$: relational contracts are self-enforced when $\delta V > (1-\delta)h$, which means that the informal agreements are sustainable when $\delta > \bar{\delta} = \frac{h}{h+V}$.

the idea that a key factor of contractor opportunism is the availability of alternative suppliers. As soon as competitive pressure allows the buyer to replace his seller easily, the potential success of seller opportunism is reduced and agreements can be less complete.

***Proposition 2.b.*** *The higher competitive pressure is, the more sustainable relational contracts become.*

In this section 4, we have shown that the buyer has two ways of avoiding being held up. He can choose to have as complete a formal contract as possible (subsection 4.1), and supports ex-ante costs to learn about future contingencies, avoiding inappropriate design. This solution is costly, but allows him to avoid renegotiations with the risk of hold-up. The second option (subsection 4.2) is to propose a relational contract to the seller, i.e. a higher probability of being renewed if she does not hold up in the event of inappropriate contractual design. This solution is not costly, but it is uncertain. The seller commits to her informal agreement, if she is patient enough, and/or if the value of the relationship is high enough, and/or if the competitive pressure is high. In the following section, we show how the buyer chooses between these two solutions, and how this choice changes over time.

## 5. Trade-off between the two strategies

*5.1. A learning process to learn the sustainability conditions of the relational contract*

In our model, contrary to the main literature on relational contract, the buyer is unaware of the values of $\delta$ and V for the seller, which is his partner's private information. He cannot know whether the relational contracting strategy is sustainable or not. He is aware that sustainability depends on the values V and $\delta$, but does not know the true values of these parameters for the seller.[17] To try to determine whether an informal agreement will be sustainable or not, he has to guess what the values V and $\delta$ are for the seller. In other words, he has to determine whether the seller considers the transaction has a high value (a high V) or not, and whether the seller is patient or not ($\delta$), that is, whether she valorizes future gains or prefers present benefits. As noted by Crocker and Reynolds (1993), although a contractor's likelihood of engaging in opportunistic behavior cannot be observed directly, past experience may serve as a useful guide. Crocker and Reynolds argue, and prove empirically, that agents with a historical propensity to cooperate in resolving contractual disputes are more likely to take the longer view in an exchange relationship, whereas those who have been opportunistic and litigious in the past would be likely to be so in the future.[18] In this section, we detail how the buyer learns about the

[17] We can legitimately assume that B knows the level of competitive pressure on the market. That's why we consider that he is only unaware of parameters $\delta$ and V.

[18] In their empirical analysis, Crocker and Reynolds use a variable *Disputes* (defined as the number of cases argued and determined involving the contractor, the parent company, or other subsidiaries for the five years preceding the date of a contractual observation) to capture this reputational effect. They show that a history of litigiousness generates more complete agreements, which is consistent with our results.

types of the sellers over time, and how this learning process determines the dynamics of contractual incompleteness. More precisely, we show that, at the beginning of the relationship, the buyer has no information, that is, he does not know whether an informal agreement is sustainable. He is then reluctant to rely on the relational strategy. He prefers to invest ex-ante to have a formal contract that avoids renegotiations. However, since $T'(1) \to \infty$, the contract is never totally complete in spite of the high contracting costs incurred by the buyer, and renegotiations arise progressively . As times goes on, the buyer observes the behavior of the seller during renegotiations, and learns how she reacts. In this way, he collects information about the seller, and is more able to determine whether or not she is patient, and whether or not she gives a high value to the transaction. This learning process allows the buyer to know whether informal agreements are likely to become sustainable. Then, trust may grow up over time, which gives the buyer more confidence in the relational strategy. He will choose this strategy to avoid hold-up, and spend fewer ex-ante contracting costs. In a nutshell, we show how the trade-off between the solutions avoids hold-up changes over time. Next, we detail the learning process thanks to which the buyer learns about the seller, and show the implications for the ex-ante contracting costs (which diminish over time).

*5.1.1. Types of seller*

As previously said, we assume that B does not know V and $\delta$, but knows that there are two different kind of sellers:

- **Type 1 sellers** are very patient and attribute strong value to the future, i.e. have a high $\delta$, so that $\delta > \bar{\delta}$. Whatever the value of V, relational contracts are sustainable. These sellers are capable of credible commitments and bind themselves to respect the spirit of the contract.

- **Type 2 sellers** are much more impatient, i.e. have a lower $\delta$. Their willingness to cooperate depends on the value of V. Relational contracts are sustainable if (and only if) V is high enough.

The goal of the buyer is to select type 1 sellers, to be certain that relational contracts will be sustainable, whatever the value of the transaction through time.

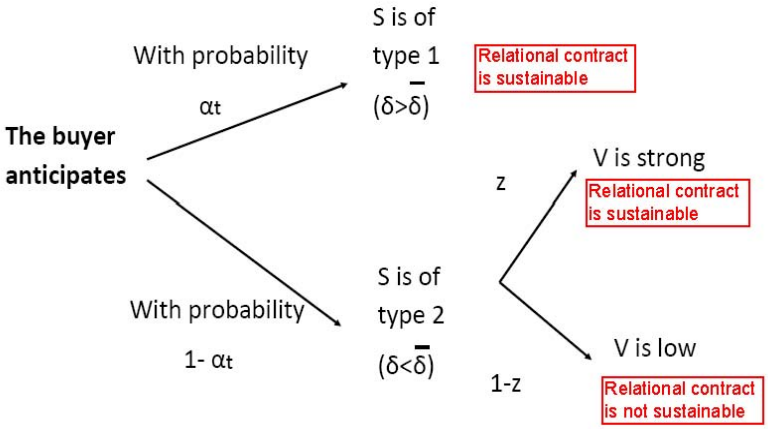
*5.1.2. Anticipation of seller's behavior*

The buyer formulates subjective probabilities to try to guess his partner's ability to commit to a relational agreement. Let $\alpha_t \in [0;1]$ be B's subjective probability at the start of period t that the seller is type 1, i.e. the probability that the seller is very patient.[19] As a consequence, at each period t, there is a probability $(1 - \alpha_t)$ that the seller is type 2, and may choose not to respect her informal agreement, according to the value of V. Whenever a new contractual relationship begins with a new seller, for period 0 of the relationship, $\alpha_0$ is the expected fraction of type 1-

[19] $\alpha_t$ can be considered as reputation of reliability parameter as in Banerjee and Duflo (2000): In their model, the client puts a probability $\theta$ on the firm's reliability on the basis of what he knows of the firm. Therefore, $\alpha_t$ mesures reputation.

sellers among the population, and is also common knowledge.
We assume that $z \in [0;1]$ is the proportion of type 2 -sellers who attribute a high value to V.[20] For instance, they may have few business contracts or different future contracts, whose attribution is connected to reputation based on the contract with B. Alternatively, the seller may believe that communication between different buyers is good enough to prevent other contracts being signed with others buyers in case of hold-up, so that they prefer not to hold up, because $p_l$ will tend towards zero for many other contracts.

Figure 5: Anticipations of the buyer at period t




The probability $\alpha_t$ formulated by B about S's type is revised at each period t, by taking into account "good" ($h_{i\in[0;t-1]} = 0$, i.e. no hold-up) or "bad" behavior from S ($h_{i\in[0;t-1]} = 0 \neq 0$, i.e. hold up) in the previous period, that is whether or not she has reneged in the event of inappropriate contractual design. If the contractual design was appropriate at period t, then $\alpha_{t+1} = \alpha_t$, because B has no additional information to revise his subjective probability. Yet, if the contractual design was inappropriate, then the probability that S is of type 1 can be revised at the next period[21]:
To determine the probability $\alpha_{t+1}$ that in period $t+1$ the seller is type 1, the buyer observes S's past behavior. If S did not hold up before, then $h_0 = 0$, ...,$h_{t-1} = 0$. Then, the adaptation formula follows from Bayes' law:

$$\alpha_{t+1} = Prob(Type1/h_t, h_{t-1}, ... = 0) \tag{5}$$

[20]For simplicity's sake, $z$ is common-knowledge: once B knows that S is type 2, he knows that $z$% of type 2- managers have a high value of V. For instance, B knows that his contract represents an important market share for S, so that V is high for S. As a consequence, uncertainty is mainly about the extent of S's patience ($\alpha_t$).

[21]This demonstration is similar to the way adaptive anticipations are modeled in macroeconomic models, like Barro (1986) which study reputation in a model of monetary policy with incomplete information.

$$= \frac{Prob(Type1/h_{t-1}, ... = 0) \times Prob(h_t = 0/type1)}{Prob(h_t = 0/h_{t-1} = 0, ...)}$$

$$\alpha_{t+1} = \frac{\alpha_t \times 1}{\alpha_t + (1 - \alpha_t)z}$$

As $0 \leq \alpha_t \leq 1$, and $0 \leq z \leq 1$, then $\alpha_{t+1} \geq \alpha_t$. In other words, the observation of $h_t = 0$ raises the buyer 's confidence that S respects their informal dealings. On the opposite, if S holds up at stage $t$ (the buyer observes $h_t = 1$), then $\alpha_{t+1} = 0$ since B immediately knows that S is type 2.

This allows us to show that the buyer revises his beliefs whenever he can, i.e. whenever he has the chance to learn something about the type of seller.

- If the contractual design A is appropriate (with probability $(1 - \rho)$), then $\alpha_{t+1} = \alpha_t$. B has no new information between t and $t+1$ to revise his subjective probability upwards or downwards.
- If the contractual design is inappropriate (with probability $\rho$), and S does not hold up B (with probability $(1 - x)$), then $\alpha_{t+1} > \alpha_t$.
- If the contractual design is inappropriate (with probability $\rho$), and S holds up B (with probability $x$), then $\alpha_{t+1} = \alpha_{t+2} = .... = 0$. B knows that S is untrustworthy, and no longer proposes a relational contract. He selects another seller at the next contract renewal point with probability $p_l \leq p_h$.

To sum up, we show that the buyer anticipates S's ability to commit to her informal promise. He formulates beliefs about her reputation for reliability. If the seller is honest, the buyer is able to gauge this over time. As a consequence, the more past experiences the two partners have, the more trust grows between them. Relational contracts are likely to become more and more self-enforceable.
Let us now look at how this result impacts on the degree of formal completeness of the contract.

*5.2. Consequences for the costs of additional completeness*

The two strategies described in section 4 are not exclusive. The buyer may invest in costs of additional completeness $T_B(k)$, and also propose a relational contract. The level of costs $T_B(k)$ is connected to the degree of trust B has in the relational contract. We demonstrate such an intuition in this subsection.

Remember that from (3):

$$T_B^{'}(k) = \rho[a + xh]$$

$x$ represents the probability that S holds-up B, when the contractual design is inappropriate. As we previously said, $x$ cannot be considered exogenous. By introducing anticipations based on the observation of past experiences, we basically endogenize this probability, and proposition 2.a. shows that $x = x(V, \delta)$.
$x$ is now equal to the probability that S is type 2 and attributes a low value to $V$, i.e. $x_t = (1 - \alpha_t)(1 - z)$.

If we denote $T'_{B,t}(k)$ the level of costs of additional completeness supported by B before each contractual period t, then :

$$T'_{B,t}(k) = \rho[a + (1 - \alpha_t)(1 - z)h]$$

*5.2.1. No hold-up in past experiences*

Let us assume here that there has been no hold-up between the parties during past experiences. There may be two reasons for this. First, the design was appropriate, so no renegotiation occured. As previously shown, the buyer's anticipation of seller type does not change ($\alpha_{t+1} = \alpha_t$). A second scenario is that the design was inappropriate, but the seller chose to respect her informal dealing, and did not hold up B. In this situation, we have shown that $\alpha_{t+1} > \alpha_t$.

Since in the absence of hold-up $\alpha_{t+1} \geq \alpha_t$, then $(1 - \alpha_{t+1}) \leq (1 - \alpha_t)$ and

$$T'_{B,(t+1)}(k) \leq T'_{B,t}(k) \tag{6}$$

By recurrence:

$$T'_{B,(t+n)}(k) \leq ... \leq T'_{B,(t+1)}(k) \leq T'_{B,t}(k) \tag{7}$$

Moreover, because of increasing-convexity of function $T$, then

$$T_{B,(t+n)}(k) \leq ... \leq T_{B,(t+1)}(k) \leq T_{B,t}(k) \leq ... \leq T_{B,0}(k)$$

This means that the optimal levels of ex-ante contracting costs decrease over time. For each new potential partner, $T_{B,0}(k)$ is the same at period 0 of the relationship, as $\alpha_0$ represents the probability of type1-sellers in the whole seller population. Then if the seller chosen at period $t = 0$ is honest, at each next contract period, she is more likely to be chosen again, as the costs of additional completeness supported by B are lower than they would be with a change of partner. For instance, at period $t$, if B decides to choose another seller to perform the service, he bears $T_{B,0}(k)$, while if he continues the contractual relationship with the previous seller, he supports $T_{B,t}(k) \leq T_{B,0}(k)$. This result shows that there may be some rationale to selecting the same partner over time, if the production costs proposed by the other potential partners are similar.

As a consequence, not only has B greater interest in renewing the contract with the same seller, but this contract becomes more and more incomplete over time, since the optimal level of ex-ante contracting costs decreases over time.

This leads to the following proposition:

**Proposition 3.a** *Suppose that B chooses the same seller during several contractual periods, and that S has not held him up. The level of costs of additional completeness supported to anticipate future contingencies decreases over time. As a consequence, the seller is more likely to be renewed, and the contracts between the two partners become more and more incomplete over time.*

As a consequence, we show that, over time, the partners' mutual trust about their ability to commit to an informal dealing increases. This makes relational contracting easier to enforce. Then, the rationale becomes to spend less on additional completeness. The buyer can save on these ex-ante costs, while still avoiding being held-up if the contract proves to be incomplete.

*5.2.2. Hold-up in past experiences*

Let us assume now that the seller holds up at period $t$. She is immediately identified as a type 2 seller by the buyer. For the following periods, the buyer anticipates that she will not respect her informal commitment[22], i.e. $\alpha_{t+1} = 0$.
Then, the buyer has two solutions:

- If he decides not to renew S, he begins a new relationship with another seller. In that case, he supports some contracting costs $T'_{B,0}(k)$, that is, the level of ex-ante contracting costs at period 0 of the relationship (determined by the exogenous probability $\alpha_0$ defined earlier). However, it implies that B can find another seller on the market, in other words, has the ability to punish S by not renewing her. Earlier we defined this probability by $(1 - p_l) \geq 0$[23], so we have to explore the second scenario, that is, the constrained renewal of S.

- If B decides to renew S, the optimal level of ex-ante contracting costs at period $T \geq t + 1$ is given by:

$$T'_{B,HU,T}(k) = \rho[a + (1 - z)h] \tag{8}$$

  where $T'_{B,HU,T}(k)$ is the optimal level of marginal ex-ante contracting costs when the seller is not trustworthy (at period T), because of past hold-up. We have replaced $\alpha_t$ by 1 because there is no more uncertainty about the type of the seller (type 2).

  Since $\alpha_t \geq 0$, then $T'_{B,HU,T}(k) > T'_{B,T}(k)(= \rho[a + (1 - \alpha_t)(1 - z)h])$.

  This means that the optimal level of ex-ante contracting costs is higher than the alternative situation, where the buyer has imperfect information about the seller type, and tries to guess it. This result can be interpreted as follows: since the buyer is certain that the seller is a type 2 seller, no relational contracting can be sustained. Then, there is no other solution than to design as complete a contract as possible to prevent renegotiations, that will necessarily lead to hold-up. In other words, if S is renewed, contracts become more complete than in the past transactions, since the buyer is now aware of the inability to implement relational contracts.

[22] We have made the assumption that S has no strategic behavior. However, we are aware that such an assumption could be changed, and we reserve the analysis of strategic behaviors to further works.

[23] When S is a type 2 seller, B renews her with probability $p_l$. As a consequence, $(1-p_l)$ represents the probability not to be renewed when S held up.

**Proposition 3.b** *Suppose that S held B up, and is still renewed. The optimal level of costs of additional completeness supported to anticipate future contingencies become higher than in past transactions. As a consequence, once the hold-up has occured, contracts between the same partners become more complete.*

## 6. Conclusion

In this article, we examine why relational contracting can also be considered a factor of contractual incompleteness. Our model shows that contractors have two strategies to avoid hold-ups. They can either support some costs of additional completeness to learn about future contingencies, and draft the contract to minimize ex-post contractual renegotiations that allow room for hold-up; or, they can rely on informal cooperation. Our results show that building trust over time allows parties to implement informal agreements. As time goes by, parties are all the more willing to propose relational agreements, which allows them to save on ex-ante contracting costs. Our main contribution is to prove that relational contracts help to save costs spent on learning about future contingencies, and writing as complete a contract as possible. Informal dealings avoid parties spending too much on costs of additional completeness before signing the contract, because they make it possible to avoid hold-up in the case of contractual incompleteness. When trust is built up over time, parties no longer fear incomplete contracts. Our conclusion is that relational contracting generates contractual incompleteness: because partners rely on their tacit dealing to manage ex-post adaptations, they accept incomplete contracts. Contractual incompleteness can be a deliberate choice for both parties. On the contrary, when relational contracts are not sustainable, parties prefer sign more complete contracts. Further research should extend our work. One way to do this could be to explore the strategic behavior of the sellers, who could choose to cooperate during several periods, and then deviate to gain a larger amount of hold-up.

Our results also suggest that contracts can be more and more incomplete over time, which may sound surprising. An alternative is to consider that initial contracts are voluntarily incomplete, but will become more complete over time. This monotonic relationship is a consequence of the progressive resolution of technological and intertemporal uncertainties as events unfold, which appears to be the driving force behind the design of the contract (Crocker and Reynolds, 1993): parties voluntarily sign an incomplete agreement and progressively complete it over time. In our paper, we depart from this view because, if both parties trust their co-contractor, incompleteness is the result of fewer ex-ante contracted on both sides. As a consequence, there is a strong condition to have more and more incomplete contracts: Relational contracts have to be self-enforceable. If this condition is not fulfilled, contracts can become more complete, which is consistent with previous results on the subject (Battigalli and Maggi, 2008; Crocker and Reynolds, 1993). For this reason, we highlight that relational contracts are not only a response to contractual incompleteness but also a cause of it. To illustrate how contracts can evolve toward more incomplete agreements, McNaugher (1989) shows that unanticipated problems can result in backtracking. Refereeing to the case of submarine procurement for the US Navy, McNaugher shows that the initial fixed-price agreement was replaced by

a less complete contract where renegotiations were permitted ex post. Moreover, our result can be interpreted relatively if we compare the evolution of contractual agreements. For instance, we can consider a buyer B who starts relationships with two different sellers, X and Y. According to our model, if B learns during his relationships that X is a type 1 seller and Y a type 2, he will incur more costs in crafting a complete agreement with Y than he would with X. As a result, the contract with X becomes more incomplete over time, compared to the contract with Y.

Finally, the main point is that the dynamics of contractual incompleteness and heterogeneity across relationships are influenced by past contractual experimentations by both parties. This clearly calls for empirical investigation of our propositions, which could be done by analysing the contractual history of partners in inter-firm relationships and public procurement agreements. Experimental economics could also help us to obtain data, to test whether the perspective of future business allows saving on the costs of writing formal agreements. This could help us to make a qualitative analysis of contractual relationships, and to build a general theory of relational contracting and contractual incompleteness.

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