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The value of cooperative investment in nonexclusive contracts

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Abstract

This article examines the incentives for a buyer to undertake relationship-specific investment in the presence of multiple suppliers who provide a homogeneous input. When multiple suppliers compete for a single buyer, the buyer's investment affects its outside option in the event of a relationship breakdown. Relationship-specific investment with a supplier thus reduces the buyer's outside option, were there to be a supply breakdown with this supplier, but increases the buyer's outside option with respect to a supply breakdown of competing suppliers. The extent to which suppliers offer trading contracts designed to substitute the trade loss from a relationship breakdown, therefore shapes the changes in the buyer's outside option and its incentives to invest. The present paper shows that introducing competition to one side of the market reduces the hold-up problem associated with relationship-specific investment and establishes conditions where investment does not materialize.

Keywords: Specific investment, Outside option, Relationship breakdown.

JEL classification: D44; L11.

1. Introduction

Many customer-supplier trading relationships in the outsourced manufacturing industry are characterized by collaboration on cost-reducing design innovations and competition over prices. Whitford (2005) calls this phenomenon "contested collaboration", with original equipment manufacturers (OEMs) constituting one example. In OEM transactions, a brand-name company provides detailed technical blueprints, key technology, and timely information to allow production by suppliers according to specifications (Ernst, 2000).[2] In such cases, there is mutual adjustment in which the buyer and suppliers intermingle competitive and collaborative interactions.[3]

In this paper, we study the link between competitive and collaborative interactions when a group

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[2]OEM's such as Sun Microsystems, Cisco, HP, Nokia, and Boeing use contract manufacturing to build components, subassemblies or subsystems.

[3]In many OEM agreements, the buyer develops incremental product and process innovations to improve quality control and hold down costs (Hall and Soskice, 2001).

of suppliers competes for a single buyer who undertakes relationship-specific investments with the suppliers. A major conclusion drawn by the literature on investments is that if a principal makes an investment that is specific to its relationship with an agent, it has no effect on the principal's bargaining position with respect to that agent (see Segal and Whinston, 1986). This is because the outside option is determined by the situation in which the principal's relationship with the agent has broken down and the principal is no longer supplying, or being supplied by, the agent; the relationship-specific investment has no value in that outside option. Contrary to that conclusion a key contribution of this paper is to show that, in the event of a relationship breakdown, the relationship-specific investment can still matter for the outside options where there exist multiple suppliers.

Consider a situation when a buyer negotiates with multiple suppliers and decides how much to trade with each of them. In the presence of multiple suppliers, the buyer's outside option of a relationship breakdown depends on the gains from trade that can be generated with the rest of the suppliers, and relationship-specific investment affects those gains. When a buyer invests with a supplier, this supplier becomes more efficient in input production, as the investment reduces the supplier's cost of production relative to that of its rival suppliers who do not receive investment. Then, the outside option available to the buyer, after not trading with the invested supplier, shrinks (the supplier becomes more essential to the buyer), but the buyer's outside option in the event of a relationship breakdown with any rival supplier grows (the supplier becomes less essential to the buyer). In summary, with a relationship breakdown, a relationship-specific investment will change the buyer's outside options affecting its bargaining power and incentives to invest.

A central component in eliciting how investment changes the buyer's outside option is the number of suppliers who offer trading contracts designed to substitute the trade loss from an excluded supplier. There is evidence of OEM suppliers offering a menu of contracts with such trading contracts when competing for a single buyer. Solectron, a leading contract manufacturer for many electronics firms, established quantity flexibility contracting agreements with both its customers and its raw materials suppliers specifying different trade quantities in case of trade breakdown with a supplier (Ng, 1997). Nippon Otis, a manufacturer of elevator equipment, implicitly used quantity flexibility contracts with Tsuchiya, its supplier of parts and switches (Lovejoy 1999).[4] Building on common agency models, which consider competition between multiple principals and a single agent (see Segal, 1999; Chiesa and Denicolò, 2009, 2012), we will use the notion of "latent" contracts. Latent contracts are trading contracts designed to restore the trade loss from a relationship breakdown and, thus, determine the

[4]Other examples are Toyota Motor Corporation, IBM, Hewlett Packard, and Compaq.

buyer's available outside option after a supply breakdown. In the analysis, we construct and select equilibria depending on the group of suppliers who offer latent contracts.

The underlying structural factors that cause suppliers to offer trading contracts that take into account a relationship breakdown of the buyer with a competing supplier (latent contracts) may vary from industry to industry. For instance, suppliers that offer latent contracts may have a better knowledge of the functioning of the market; they may have already transacted with the buyer in previous periods and know that the buyer will restructure trade after a supply breakdown. Andrabi et al. (2006) find evidence in the Millat Tractors in Pakistan that, on average, a vendor may be contracted to supply three times more than another vendor supplying the same part, in the same year, and, consequently, may end up acquiring a better knowledge of the market functioning. Asanuma (1988) states that in the Japanese automobile industry, first-tier vendors are recursively supplying transacted parts and engage in renegotiations on business terms with a common big buyer at regular intervals. He also gives evidence of different contractual relations in the electric machinery industry; in this sector, basic contracts tend to be more inflexible as they do not contain stipulations for re-contracting. Plambeck and Taylor (2007) state that in biopharmaceutical manufacturing Lonza's manufacturing facilities can readily be adapted to produce various proteins. When one buyer has greater demand than anticipated and another buyer has low demand Lonza negotiates flexible re-contracting with the buyers to achieve a more profitable allocation.

This paper shows that the buyer only invests in those suppliers who offer latent contracts. Those contracts substitute the trade loss that would originate from a supply breakdown, so investment with a supplier makes such trade substitution cheaper, thus providing the buyer with a better outside option. Relationship-specific investment then increases the buyer's bargaining power with respect to competing suppliers, which allows for part of the gains that its investment generates to be appropriated. Relationship-specific investment, however, reduces the buyer's bargaining position with respect to the supplier in whom it invests. Investment reduces the trade of competing suppliers, so it becomes more expensive to substitute the trade loss of a relationship breakdown with the invested supplier. The supplier who receives the investment appropriates more than the direct gains from the investment and the buyer's bargaining position reduces. If the loss in the buyer's bargaining position is large enough, such a loss can altogether eliminate the gain that the buyer obtains from the competing suppliers and the buyer may decide not to invest. Nevertheless, we show that when all of the suppliers offer latent contracts, the buyer always invests. In this case, a supplier only appropriates the direct gains from the investment, and the investment always reduces the equilibrium payoffs of the competing suppliers.

A secondary result of the analysis is that the buyer's incentives to invest generate differences in the market structure. The evidence indicates that, in the automobile industry, most of the suppliers that provide intermediate and final components have a close trading relationship with the big buyers who make key investments with them. By contrast, in the information technology industry, the production of first-tier suppliers, in whom the buyer undertakes relationship-specific investment, is complemented by second-tier suppliers in whom the buyer does not invest; Dell trades with several suppliers who have a dominant position compared to their rivals (Kang et al., 2007). Our model suggests that the offering of a rich menu of contracts (latent contracts) gives rise to a more homogeneous set of suppliers, as all of them receive a specific investment from the buyer, when compared to a scenario with a less rich menu of contracts (some suppliers do not offer latent contracts) in which we may expect first-tier and second-tier suppliers to coexist.

The model shows that the introduction of competition to the supply side of the market is necessary, but not sufficient, to fight against the hold-up problem. The suppliers' offerings of contracts designed to replace the loss of trade from a relationship breakdown are essential to determining the buyer's incentives to invest: when more suppliers submit those latent contracts, the buyer's outside option after a supply breakdown increases. A better outside option increases the buyer's bargaining position with respect to suppliers, with the former being able to appropriate part of the gains from trade that its investment has generated. Accordingly, the problem of being held up reduces and the aggregate level of specific investment grows. However, because suppliers always appropriate the direct gains from investment, the full efficient investment level cannot be implemented.

This article contributes to the growing literature on flexibility in outside options. There has been considerable exploration of the bargaining model proposed by Horn and Wolinsky (1988) and whether their assumptions about behavior, after a breakdown in negotiations, are too restrictive. Ho and Lee (2019) develop a bargaining solution that captures the incentive to exclude. In their model, a principal can threaten to replace an included agent with an excluded alternative agent when bargaining. An agent obtains the price that would make the principal indifferent between keeping the agent and replacing the agent with any excluded alternative agent at the minimum price the alternative agent would be willing to accept. In their model, excluding an agent from a trading network then works as a commitment for the principal to improve its bargaining position with the agents who belong to the network.[5] In Leibman (2018), upon disagreement in bargaining, a replacement is randomly chosen from among an exogenous set of acceptable agents. In our model, which differs from these previous models, exclusion never happens in equilibrium, so the suppliers equilibrium payoff is determined by the threat of being excluded from trade. A supplier's threat of exclusion depends on the available

[5] This is the Nash-in-Nash with Threat of Replacement bargaining solution.

outside option of the buyer if a relationship breakdown with its supplier were to occur, and that outside option is affected by the buyer's relationship-specific investment allocation

The present work also relates to the literature on incentives to undertake specific cooperative investment. Che and Chung (1999), Che and Hausch (1999), and Hori (2006) show that, when relationship-specific investment is cooperative, the implementation of simple ex-ante contracts is not sufficient to restore an efficient level of investment.[6] Without renegotiation, contracting has no value. Che and Chung (1999) study different breach remedies and conclude that an efficient investment can only be achieved whenever trading parties are allowed to renegotiate ex-post. Examples of this include the use of contracts that lock in supplier-customer arrangements for several years, or the use of contractual penalties if the relationship is discontinued (Harford et al, 2018). Departing from contractual remedies offered by the literature, we investigate whether the introduction of competition to one side of the market can lessen the hold-up problem.[7]

The literature that studies competition and the hold-up problem emerged as a result of the impossibility of designing and enforcing ex-ante contracts in environments that are affected by the hold-up problem. Mailath et al. (2013), and Felli and Roberts (2016) study a matching market where once the investment has been made, the agents decide on the trading partner. They show that the presence of market competition for matches provides incentives for investment. Although investment incentives are taken into account, inefficiencies due to coordination problems may arise. In Cole et al. (2001a, 2001b), the matching process is modeled as a cooperative assignment game and, while efficient matching always happens in equilibrium, efficient investment does not emerge. Departing from these previous studies, which consider a cooperative environment, we study a non-cooperative game where trade is modeled following the markets and contracts literature in which there is competition between multiple suppliers that each simultaneously offer bilateral contracts to a buyer.[8]

We borrow from the literature on markets and contracts to model competition between multiple principals and a common agent (see Bernheim and Whinston, 1986; and Chiesa and Denicolò, 2009). In our common agency game, trade is modeled as a first-price auction in which the principals

[6]In contrast with selfish investment, i.e. investment that directly benefits the investing party (a seller who invests in reducing her cost or a buyer who invests to increase his benefit from the procured good or service), simple (incomplete) contracts can solve the hold-up problem (see, e.g. Chung (1991), Rogerson (1992), Aghion et al. (1994), Nöldeke and Schmidt (1995), Edlin and Reichelstein (1996), Konakayama et al. (1986), and Schmitz (2002b)).

[7]For an early formulation of the hold-up problem, see Klein, Crawford, and Alchian (1978), Hart and Moore (1990, 1999), and Williamson (1979, 1983).

[8]The study of competition in a non-cooperative game, and the hold-up problem, together with elements of organizational design is considered in Cai (2003) and Chatterjee and Chiu (2007). Göller (2019), studies a bilateral investment game in a design mechanism environment and shows that it is in the agent's best interest to endogenously prevent the possibility of ex-post renegotiation.

simultaneously submit a menu of trading contracts and a common agent chooses a single contract from each principal. Common agency games have multiple equilibria. The equilibria do not differ in the level of trade, which is always efficient, but in the distribution of the trading surplus among the players. In our model, all equilibria of the game have the same structure; when suppliers are making simultaneous offers to the buyer, each supplier makes the buyer indifferent between accepting or rejecting its offer. If an offer is rejected, the buyer obtains its outside option, which depends on the number of suppliers offering latent contracts.[9] The distribution of the gains from trade is important to the extent that it determines a player's incentives to invest in an earlier stage. We then add to the literature the decision of a common buyer to establish a relationship-specific investment with suppliers. This allows us to study the effects of competition on the hold-up problem.[10]

Finally, our model is similar to that of Inderst and Wey (2006, 2011), and Vieira-Montez (2007) who study the effect of buyer power on suppliers' incentives to invest. The formation of a large buyer may strengthen suppliers' incentives to invest. In Inderst and Wey (2006), when facing larger buyers, a supplier wants to invest more in product innovation than when trading with smaller buyers; such investment makes it possible to accommodate the loss of a large individual order by increasing sales to other buyers. In Vieira-Montez (2007), an increase in the bargaining position, as a result of a downstream merger, induces larger investment in capacity by an upstream firm. In Raskovich (2003), a pivotal buyer is responsible for ensuring that the supplier's costs are covered. In his model, the buyer gives more rent to the supplier to satisfy his participation constraint, which increases the supplier's incentives to invest. Battigalli et al. (2007) study the impact of buyer power on a supplier's incentive to improve quality, and they show that an increase in buyer power may be detrimental to welfare by leading to quality deterioration. We also find that an increase in the bargaining position of suppliers may have detrimental effects on the buyer's investment. The buyer's investment increases the suppliers' bargaining positions whenever some of the suppliers do not offer latent contracts, but the buyer's increase in bargaining power over competing suppliers is what provides the buyer with the incentives to invest.

The remainder of this article is structured as follows. Section 2 describes the model and elicits efficient trade. We then study a buyer's incentives to invest in a nonexclusive trading game. By backward induction, Section 3 characterizes the equilibrium of the trading game, and we later proceed

[9]In most of the common agency literature, attention is restricted to the truthful equilibrium, but a few papers have also considered the equilibrium that is Pareto dominant for the principals (sometimes referred to as the minimum rent equilibrium). In our model, we recover both equilibria depending on the set of suppliers that offer latent contracts.

[10]Chiesa and Denicolò (2012), study both the decision of a common principal to build productive capacity with a group of agents, and the pro-competitive effects of mergers.

with defining the equilibrium investment allocation of the buyer. We discuss results regarding the equilibrium market structure. Section 4 compares the equilibrium allocation with efficiency, and Section 5 concludes. All proofs not included in the main text can be found in the appendix.

2. Model and preliminary results

We consider a nonexclusive trading game where a single agent (buyer) invests with N principals (suppliers) who each produce a homogeneous input.[11] The game consists of two stages played sequentially. In stage 1, the common buyer decides the amount of investment directed to any supplier. Then, $k_i \geq 0$ represents the investment to supplier $i \in N$, and the vector $\mathbf{k} = (k_1, k_2, ..., k_N)$ stands for the investment allocation. By $\mathbf{k}_{-i}$, we denote the vector of investment containing all investments except the investment for supplier i, and $K = \sum_{i=1}^{N} k_i$ represents the total investment.[12] In stage 2, trade takes place. Following Chiesa and Denicolò (2009), we model trade as a first-price auction in which suppliers simultaneously submit a menu of trading contracts and the buyer chooses a single contract per supplier.[13] By $M_i \subset \mathfrak{R}^2_+$, we denote the menu of trading contracts provided by each supplier, where a trading contract consists of a pair $m_i = (x_i, T_i)$. Accordingly, $x_i \geq 0$ is the quantity of input supplied, and $T_i \geq 0$ is the corresponding total payment. Common agency is private (the payment to a supplier depends only on the quantity it supplies) and delegated (the buyer can choose which supplier to trade with). The game is of complete information and is formally explained as follows.

Strategies and payoffs

A strategy for a generic supplier i is a set of contract menus $M_i \subset \mathfrak{R}^2_+$. With a profile of menu contracts $\mathbf{M} = (M_1, M_2, ..., M_N) \in \Gamma^N$, a strategy for the buyer is a function $\mathcal{M}(\mathbf{M}) : \Gamma^N \to (\mathfrak{R}^+)^N$ such that $\mathcal{M}(\mathbf{M}) \in \times_{i=1}^{N} M_i$ for all $\mathbf{M} \in \Gamma^N$. We denote $\mathbf{m} = (m_1, m_2, ..., m_N)$ as the vector of contracts accepted by the buyer, with one contract selected for each supplier. Later, when describing the equilibrium in the trading game, we select equilibria depending on the trading contracts that

[11] The results of the paper do not depend on the inputs offered by the suppliers being homogeneous; however, allowing for input heterogeneity would complicate the analysis without generating any qualitative difference in our main results.

[12] We consider the investment of the buyer, instead of the suppliers, to make the model interesting. The incentives to invest would be straightforward if we were to consider the investment of suppliers, and one would regard them as industry-specific investments rather than relationship-specific.

[13] Modeling competition with menus of trading contracts is a generalization of trading interactions. It corresponds to a natural extension of the standard model of Bertrand competition where the agent is a consumer who purchases a good from various firms that compete in no-linear prices.

suppliers include in their menu; however, because trade is voluntary, each supplier $i \in N$ must offer the null contract $m_i^0 = (0, 0)$.[14]

We consider a quasilinear environment where, for a given vector $\mathbf{m}$ of contracts accepted by the buyer, the vector $\mathbf{k}$ of the investment allocation, and N suppliers, the buyer's payoff is:

$$\Pi(\mathbf{m} \mid \mathbf{k}) = U(X) - \sum_{i=1}^{N} T_i - \phi(K), \tag{2.1}$$

where $X = \sum_{i=1}^{N} x_i$ represents the total input traded and the function $U(X) : \mathfrak{R}^+ \to \mathfrak{R}^+$ denotes the monetary value to the buyer. Function $\phi(K)$ represents the monetary cost of generating the total investment K.

The payoff for each supplier i is:

$$\pi_i(m_i \mid k_i) = T_i - C_i(x_i \mid k_i); \quad \forall i \in N, \tag{2.2}$$

where $C_i(x_i \mid k_i) : \mathfrak{R}^+ \to \mathfrak{R}^+$ is the production cost function of supplier i that depends on the investment k_i.[15] Direct externalities do not arise in the model because the production cost function of each supplier depends only on the received investment from the buyer and its own output. Contractual indirect externalities arise because the quantities traded with all suppliers affect the buyer's willingness to pay for the inputs of each supplier and the cost of investment in one supplier depends on the investment in other suppliers.

The following regularity assumptions ensure that each supplier trades a strictly positive and finite quantity with the buyer. The subscripts denote partial derivatives.

Assumption 1. *(Regularity conditions)*

1. $U_x(\cdot) > 0,\ U_{xx}(\cdot) < 0,\ \phi_K(\cdot) > 0,$ *and* $\phi_{KK}(\cdot) > 0.$
2. $C_x(\cdot) > 0,\ C_{xx}(\cdot) > 0,\ C_k(\cdot) < 0,$ *and* $C_{xk}(\cdot) < 0.$
3. $\lim_{X \to 0} U_x(\cdot) = +\infty$, $\lim_{X \to \infty} U_x(\cdot) = 0$, $\lim_{x_i \to 0} C_x(\cdot) = 0$, $\lim_{x_i \to \infty} C_x(\cdot) = +\infty$, $\lim_{K \to 0} \phi_K(\cdot) = 0$, *and* $\lim_{K \to \infty} \phi_K(\cdot) = +\infty$.

For later use, we proceed to characterize efficient trade and establish its comparative statics with respect to investment.

[14] To guarantee the existence of an optimal choice for the buyer, the menu of trading contracts must be a compact set.

[15] Suppliers are ex-ante identical and are only ex-post differentiated if the buyer sets different investment levels. For the rest of the paper, we keep the index i in $C_i(\cdot \mid \cdot)$ to identify the supplier.

Efficient trade

For a given investment allocation $\mathbf{k}$ and number of suppliers N, the maximum trading surplus without investment costs is:

$$TS^*(\mathbf{k}, N) = \max_{x_1,\ldots,x_n} \left[U\left(x_1 + \cdots + x_N\right) - \sum_{i=1}^{N} C_i(x_i \mid k_i) \right]. \tag{2.3}$$

The vector of input $\mathbf{x}^* = (x_1^*(\mathbf{k}, N), x_2^*(\mathbf{k}, N), ..., x_N^*(\mathbf{k}, N))$ maximizes the expression above, and is obtained by the system of equations:

$$U_x\left(\sum_N x_i^*(\mathbf{k}, N)\right) = C_x(x_i^*(\mathbf{k}, N) \mid k_i), \quad \text{for all } \ i \in N. \tag{2.4}$$

The input $x_i^*(\mathbf{k}, N)$ for each supplier $i \in N$ represents efficient trade because the marginal cost of production of any supplier equals the marginal valuation of the buyer. For subsequent use, we denote $X^*(\mathbf{k}, N) = \sum_{i \in N} x_i^*(\mathbf{k}, N)$ the sum of the efficient input, and by $X^*_{-H}(\mathbf{k}, N) = \sum_{i \notin H} x_i^*(\mathbf{k}, N)$, we denote the sum of the efficient input without considering the input of those suppliers in $H \subset N$. The next lemma identifies how trade changes with respect to investment.

Lemma 1. *In efficient trade:*
For an investment allocation $\mathbf{k}$ *and* N *suppliers, when the buyer increases investment in supplier* i*:* (1) *trade with supplier* i *increases;* (2) *trade with other suppliers decreases (allocative sensitivity); and* (3) *the aggregate trade increases.*

$$1)\ \frac{dx_i^*(\mathbf{k}, N)}{dk_i} > 0, \quad 2)\ \frac{dx_j^*(\mathbf{k}, N)}{dk_i} < 0 \ \textit{ for all } \ j \neq i, \quad \textit{and} \quad 3)\ \frac{\partial}{\partial k_i} X^*(\mathbf{k}, N) > 0.$$

Because the buyer's investment reduces the production cost of suppliers, when the buyer invests with supplier i, this supplier becomes more efficient than its rivals. The difference in the relative production costs among suppliers makes it optimal to reallocate trade between suppliers until the marginal production costs equalize among them. We later show that this trade reallocation affects the equilibrium investment allocation (see Proposition 2). The *allocative sensitivity* is the change in the efficient trade allocation of any supplier $j \neq i$ due to an increase in investment in supplier i. Because the economy becomes more efficient after investment in supplier i, (3) states that the increase in trade with supplier i dominates the reduction in trade with the remaining suppliers and results in an increase in the aggregate trade.

3. Investment in a model of nonexclusive trade

With sequential moves, we look for the subgame that demonstrates the perfect equilibrium of the game. The analysis begins by characterizing equilibrium in the trading game and, next, it turns to the buyer's investment and the equilibrium market structure.

Trading game

In common agency games, inefficiencies may arise due to potential externalities among suppliers. In our model, because the production cost of any supplier does not depend on the production level of its rival suppliers, the payoff from a particular supplier is not directly affected by the trading contracts submitted by its rivals.[16] Then, given the menu of trading contracts for the other $N-1$ suppliers, supplier i effectively plays a bilateral trading game with the buyer and, because the supplier makes the offer to the buyer, it holds all the bargaining power of the trading surplus that remains, i.e. the gains from trade that can be generated after the buyer has accepted the offers of the competing suppliers. As a result, supplier i maximizes the potential gains from trade generated between the buyer and itself. The literature on markets and contracts calls this result *bilateral efficiency* (see Chiesa & Denicolò, 2009, p. 301) and guarantees that the trading contract that will be accepted in equilibrium contains the efficiency quantity $x^*(\mathbf{k}, N)$ as characterized in Expression (2.4). Then $m_i^* = \{x_i^*, T_i^*\}$ for $i \in N$ represents the contracts that will be accepted by the buyer.

In addition to the set of contracts that are accepted in equilibrium, suppliers can offer other trading contracts. To obtain the suppliers' transfers T_i^* from their accepted contracts, it will be useful to specify the trade that occurs in situations with a relationship breakdown, i.e. when the buyer decides not to trade with a supplier. Suppliers offer trading contracts that take into account a relationship breakdown. The common agency literature calls these trading contacts "latent" contracts. Latent contracts are not accepted in equilibrium but constrain the equilibrium transfers of any supplier because they determine the outside option available to the buyer with a relationship breakdown. These latent contracts represent the best available option of the buyer with a relationship breakdown.

We proceed to construct and select equilibria depending on the set of suppliers that supply latent contracts. There is evidence of OEM suppliers offering trading contracts that take into account possible relationship breakdowns, and it is argued that more sophisticated suppliers, who are able to forecast possible relationship breakdowns with other suppliers, are more prompt to offer such contracts. The following definition is useful for equilibrium selection.

Definition 1. *A "J-equilibrium" is an equilibrium of the trading game in which the set of suppliers $J \subseteq N$ offers latent contracts. The complementary set $J^c = \{N \setminus \{J\}\}$ do not offer latent contracts.*

For any set of suppliers in the set $J \in N$, we construct the outside option of the buyer with a relationship breakdown with supplier i. When the buyer does not trade with supplier i, it accepts its null contract m_i^0 specifying $x_i^0(\mathbf{k}, N) = 0$ and $T^0 = 0$, and the latent contracts $\tilde{m}_j = \left\{\tilde{x}_j(\mathbf{k}, N \setminus \{i\}), \tilde{T}_j\right\}$

[16]Interested readers may refer to Bernheim and Whinston (1986), and Segal (1999) for a reference on trading externalities in common agency games.

offered by suppliers $j \in J_i = \{J \setminus \{i\}\}$, which are designed to replace the trade loss from supplier i.[17] To obtain the quantity of trade in a latent contract $\tilde{x}_j(\mathbf{k}, N \setminus \{i\})$, we again apply the concept of bilateral efficiency with the restriction that the buyer does not trade with supplier i. Then, each supplier $j \in J_i$ offers a quantity of trade that maximizes the trading surplus with the buyer, i.e.:

$$\tilde{x}_j(\mathbf{k}, N \setminus \{i\}) = \underset{x_j \geq 0}{\arg\max} \left[U\left(X_{-\{j,i\}}(\mathbf{k}, N) + x_j(\mathbf{k}, N \setminus \{i\}) \;\middle|\; x_i^0(\mathbf{k}, N) = 0, J_i \right) - C_j(x_j(\mathbf{k}, N) \mid \cdot) \right], \forall j \in J_i. \tag{3.1}$$

The right-hand side contains the equilibrium amount of trade $X^*_{-\{J_i,i\}}(\mathbf{k}, N)$ from the suppliers who do not offer latent contracts, and the amount of trade specified in the latent contract that optimally replaces the loss from the excluded supplier i. When characterizing the equilibrium investment, it is useful to compare the trading quantity specified in a latent contract $\tilde{x}_j(\mathbf{k}, N \setminus \{i\})$ with the quantity offered in the accepted contract $x_i^*(\mathbf{k}, N)$. The convexity of the production cost function implies that the aggregate amount of trade is always lower if there is a relationship breakdown with supplier i, but because $\tilde{x}_j(\mathbf{k}, N \setminus \{i\})$ is designed to replace the quantity loss of supplier i, such an amount is larger than the individual quantity in the accepted trading contract. The next lemma states the result.

Lemma 2. *In a "J-equilibrium", for a given investment allocation* $\mathbf{k}$ *and* N *suppliers:*
i) A relationship breakdown with any supplier i *always generates a smaller aggregate trade*

$$X^*(\mathbf{k}, N) > X^*_{-\{J_i,i\}}(\mathbf{k}, N) + \sum_{j \in J_i} \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i).$$

ii) The amount of trade that supplier $j \in J_i$ *offers with a relationship breakdown of any supplier* i *is bigger than the accepted trading contract*

$$\tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i) > x_j^*(\mathbf{k}, N), \quad \forall j \in J_i.$$

From the result of the lemma, a direct corollary emerges.

Corollary 1. *For a given investment allocation* $\mathbf{k}$ *and* N *suppliers, the amount of trade in the latent contracts is larger in a "*J'*-equilibrium" than in a "J-equilibrium" where* $J' \subseteq J$,

$$\tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i') \geq \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i), \text{ for all } j \in J_i'.$$

With the amount of trade in the latent contracts that optimally replace any supplier i, the buyer's outside option, following a relationship breakdown with supplier i, is easily obtained by the condition of *individual excludability*. *Individual excludability* states that in equilibrium, the buyer can exclude

[17] If supplier i belongs to the set J, we have excluded supplier i in J_i as supplier i cannot offer a latent contract to replace itself.

from trade any single supplier and still earn his equilibrium payoffs. This is because the payment to any supplier i extracts the full value of its contribution, and the buyer is not worse off if supplier i exits. Then, if the buyer excludes from trade any supplier i, he must accept the contracts designed to replace this supplier, i.e. the latent contracts $\tilde{m}_j$ for $j \in J_i$. Moreover, because such contracts are designed to optimally replace the loss of trade resulting from the relationship breakdown of supplier i, there is no other combination of trading contracts that generates larger payoffs to the buyer. Then, the buyer's outside option with a relationship breakdown with supplier i becomes:

$$U\left(X^*_{-\{J_i,i\}}(\mathbf{k}, N) + \sum_{j\in J_i} \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i)\right) - \sum_{l\in N\setminus\{J_i,i\}} T^*_l - \sum_{j\in J_i} \tilde{T}_j.$$

The buyer trades the aggregate amount $X^*_{-\{J_i,i\}}(\mathbf{k}, N)$ with the suppliers who do not offer latent contracts if a relationship breakdown with supplier i were to occur, and the amount $\sum_{j\in J_i} \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i)$ with each of the suppliers who do offer latent contracts. Then, *individual excludability*, gives the equilibrium condition:

$$\underbrace{U(X^*(\mathbf{k}, N)) - \sum_i T^*_i}_{\text{Buyer's equilibrium payoff}} = \underbrace{U\left(X^*_{-\{J_i,i\}}(\mathbf{k}, N) + \sum_{j\in J_i} \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i)\right) - \sum_{l\in N\setminus\{J_i,i\}} T^*_l - \sum_{j\in J_i} \tilde{T}_j}_{\text{Buyer's outside option when not trading with supplier } i}. \tag{3.2}$$

To characterize the equilibrium transfer T^*_i, we finally make use of the notion of truthfulness. If the latent contracts are truthful, the set of suppliers in $j \in J_i$ must be indifferent between supplying their equilibrium contract and the latent contract, i.e.:

$$T^*_j - C_j(x^*_j(\mathbf{k}, N)) = \tilde{T}_j - C_j(\tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i)) \quad \text{for } j \in J_i. \tag{3.3}$$

Summing expression (3.3) over suppliers $j \in J_i$, gives:

$$\sum_{j\in J_i} \left[T^*_j - C_j(x^*_j(\mathbf{k}, N))\right] = \sum_{j\in J_i} \left[\tilde{T}_j - C_j(\tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i))\right], \tag{3.4}$$

and introducing this result into the *individual excludability* condition in (3.2) gives the equilibrium transfer for supplier i as:

$$\begin{aligned} T^*_i(\mathbf{k}, N \mid J_i) = U(X^*(\mathbf{k}, N)) - U\left(X^*_{-\{J_i,i\}}(\mathbf{k}, N) + \sum_{j\in J_i} \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i)\right) \\ + \sum_{j\in J_i} \left[C_j(\tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i)) - C_j(x^*_j(\mathbf{k}, N))\right]. \end{aligned} \tag{3.5}$$

In equilibrium, the transfer that a supplier receives takes into consideration that supplier's contribution to the surplus and, as the next lemma states, it depends on the number of suppliers that submit latent contracts.

Proposition 1. *For a given investment allocation* $\mathbf{k}$ *and* N *suppliers, in a "J-equilibrium", the equilibrium payoffs for each supplier and the buyer are, respectively:*

$$\begin{aligned} &\pi_i(\mathbf{k}, N \mid J_i) = TS^*(\mathbf{k}, N) - \tilde{TS}_{-i}(\mathbf{k}, N \setminus \{i\} \mid J_i); \qquad \forall i \in N, \\ &\Pi(\mathbf{k}, N \mid J) = TS^*(\mathbf{k}, N) - \sum_{i \in N} \Big(TS^*(\mathbf{k}, N) - \tilde{TS}_{-i}(\mathbf{k}, N \setminus \{i\} \mid J_i)\Big) - \phi(K), \end{aligned} \tag{3.6}$$

In the proposition, $TS^*(\mathbf{k}, N)$ is the trading surplus that can be generated given an investment allocation $\mathbf{k}$ and N suppliers. The object $\tilde{TS}_{-i}(\mathbf{k}, N \setminus \{i\} \mid J_i)$ is the maximum trading surplus that can be generated if the buyer excludes supplier i from trade. In equilibrium, each supplier obtains his contribution to the surplus, which depends on the set of suppliers $J_i = \{J \setminus \{i\}\}$ who offer latent contracts.[18]

The next corollary establishes how the suppliers' equilibrium payoffs depend on the number of suppliers offering latent contracts.

Corollary 2. *For a given investment allocation* $\mathbf{k}$ *and* N *suppliers, the equilibrium payoff of a particular supplier* i *is not increasing with the number of suppliers in the set* J_i.

The corollary states that the larger the number of suppliers that offer latent contracts, the lower becomes the equilibrium payoff for any given supplier. When more suppliers offer latent contracts, it becomes easier to replace the trade loss that results from a relationship breakdown with a supplier and the larger the outside option for the buyer becomes. A larger outside option increases the buyer's bargaining power, generating lower equilibrium payoffs for the suppliers. Thus, for a given investment profile $\mathbf{k}$ and N suppliers, the more suppliers offering latent contracts, the better the position of the buyer and the worse the bargaining position of the suppliers.

The equilibrium played in the trading game is outside the scope of this article (although we might expect equilibria with a larger number of suppliers offering latent contracts in industries where suppliers offer a richer menu of contracts). The contribution of this article is the construction of different equilibria of the trading game as a function of the suppliers offering latent contracts. Indeed, the equilibrium selection proposed in the article collapses to the two equilibria considered in common agency games. In most of the common agency literature, attention is restricted to the truthful equilibrium and the equilibrium that is Pareto dominant for the principals (sometimes referred to as the minimum rent equilibrium). In our model, the truthful equilibrium, in which each supplier obtains its marginal contribution to the trading surplus, is achieved when all suppliers offer latent contracts

[18] The conditions of *bilateral efficiency* and *individual excludability* essentially characterize the equilibrium of a common agency game; interested readers may refer to Lemma 2 in Bernheim and Whinston (1986), and the fundamental equations of Laussel and Le Breton (2001).

to replace the loss of trade from a relationship breakdown with a given supplier, i.e. $J = N$. The minimum rent equilibrium, in which the rent from each of the suppliers is maximized, is obtained when only one of the suppliers offers a latent contract.[19] In our model, different equilibria determine the partition of the gains from trade and such partition is essential in determining the buyer's incentives to invest.

With the equilibria of the trading game, we proceed to characterize the buyer's investment decisions.

Investment decisions

This section studies the buyer's investment decisions. In contrast to existing models that study relationship-specific investments, in this model the buyer invests to enhance competition among suppliers and not to increase the potential gains from trade. We show that a necessary condition to promote a buyer's investment is the existence of competition in the supply side of the market. In the presence of multiple suppliers, a buyer's investment with a supplier increases its bargaining position with respect to competing suppliers, which gives the former incentives to invest.

To understand that competition in the supply side of the market is a necessary condition to promote investment, consider first a situation with only one active supplier. Because the supplier has all the bargaining power, it gets all the bargaining surplus originating from an increase in the buyer's investment dk_1,

$$d\pi_1(\mathbf{k}, 1)/dk_1 = dTS^*(k_1, 1)/dk_1 = -C_k(x_1^*(k_1, 1) \mid k_1).$$

The buyer does not earn any profit from its investment; it is entirely held up and decides not to invest.

Now, consider a case with three active suppliers and a situation in which each supplier submits latent contracts that take into account a relationship breakdown with any of the suppliers. To study the effects of investment in the presence of multiple suppliers, take an increase in supplier 1's investment dk_1. The change in supplier 1's payoff as a result of the buyer's investment is:

$$d\pi_1(\mathbf{k}, 3)/dk_1 = dTS^*(\mathbf{k}, 3)/dk_1 - d\tilde{TS}_{-1}((k_2, k_3), 2)/dk_1 = -C_k(x_1^*(\mathbf{k}, 3) \mid k_1).$$

Similar to the case of a single supplier, supplier 1 appropriates the direct gains from the investment. The relationship-specific investment to supplier 1 does not affect the buyer's outside option with a

[19] Chiesa and Denicolò (2009) show that to guarantee the existence of an equilibrium, at least two suppliers must offer latent contracts. The latent contract from one of the suppliers replaces both the trade loss from a relationship breakdown of any other supplier and the latent contract from whichever other supplier replaces the trade loss of the supplier who offers the latent contract.

relationship breakdown with this supplier, $d\tilde{TS}_{-1}((k_2, k_3), 2)/dk_1 = 0$. This is because suppliers 2 and 3 offer latent contracts with an amount of trade $\tilde{x}_2((k_2, k_3), 2)$ and $\tilde{x}_3((k_2, k_3), 2)$ respectively, which do not depend on the investment in supplier 1. However, the investment in supplier 1 reduces the equilibrium payoff of any competing supplier $i = 2, 3$,

$$d\pi_i(\mathbf{k}, 3)/dk_1 = dTS^*(\mathbf{k}, 3)/dk_1 - d\tilde{TS}_{-i}(\mathbf{k}_{-i}, 2)/dk_1 < 0.$$

The gains from trade generated without supplier i depend on the investment in supplier 1, i.e.: $d\tilde{TS}_{-i}(\mathbf{k}_{-i}, 2)/dk_1 \neq 0$. Lemma 2, stating $\tilde{x}_1(\mathbf{k}_{-i}, 2) > x_1^*(\mathbf{k}, 3)$, and the assumption $C_{xk}(\cdot) < 0$ explains $dTS^*(\mathbf{k}, 3)/dk_1 = -C_k(x_1^*(\mathbf{k}, 3) \mid k_1) < -C_k(\tilde{x}_1(\mathbf{k}_{-i}, 2) \mid k_1) = d\tilde{TS}_{-i}(\mathbf{k}_{-i}, 2)/dk_1$, and the equilibrium payoff of supplier i decreases with the investment in supplier 1.[20] The investment with a supplier (with supplier 1) makes it less costly to substitute the trade loss from a relationship breakdown with a competing supplier (either supplier 2 or 3), so the buyer's outside option (when not trading with a competing supplier) increases. A larger buyer's outside option provides a better buyer's bargaining position with respect to competing suppliers, thus allowing the buyer to appropriate part of the gains from the trade that its investment generates. The same analysis is valid when considering an increase in investment in suppliers 2 and/or 3. In summary, the supplier who receives an investment appropriates all of the direct gains from that investment, but the equilibrium payoff of its rival suppliers decreases.

The specific investment to a supplier that generates a more favorable bargaining position of the buyer, with respect to competing suppliers, is always present when competition is introduced on the supply side of the market. Therefore, the results presented with three active suppliers are easily extended to any number of active suppliers. We later show (see Proposition 2) that, in an equilibrium of the trading game in which all the suppliers submit latent contracts, the buyer: i) always invests, and ii) sets the same level of investment in all the suppliers. By investing the same in all of the suppliers, the buyer maximizes its outside option in the event of a supply breakdown. The buyer's bargaining position is therefore maximized.

While the increase in the buyer's bargaining position with competing suppliers gives the buyer incentives to invest, there are circumstances where the buyer decides not to invest in a particular group of suppliers or decides not to invest at all. This may occur in an equilibrium of the trading game where not all of the suppliers offer latent contracts. Under such equilibrium, investment in a supplier may not increase the buyer's bargaining position with respect to competing suppliers. Additionally, a supplier who receives an investment may appropriate more than the direct gains from

[20] Lemma 2 states that $\tilde{x}_1(\mathbf{k}, 2) > x_1^*(\mathbf{k}, 3)$, but in an equilibrium where all suppliers offer latent contracts, we have that $\tilde{x}_1(\mathbf{k}_{-i}, 2) = \tilde{x}_1(\mathbf{k}, 2)$.

that investment; the investment causes trade reallocation to interfere with the buyer's outside option with a relationship breakdown with the supplier in which it has invested. The deterioration of the buyer's bargaining position, with respect to the supplier in which it has invested, may dominate the increase in the buyer's bargaining position with competing suppliers. When this occurs, the buyer decides not to invest.

To characterize these effects, consider again the presence of three suppliers but, this time, suppose that supplier 3 does not offer latent contracts. Consider the effect on the suppliers' equilibrium payoffs when there is an increase in supplier 3's investment dk_3. The change in supplier 3's payoff is:

$$d\pi_3(\mathbf{k},3)/dk_3 = dTS^*(\mathbf{k},3)/dk_3 - d\tilde{TS}_{-3}((k_1,k_2),2)/dk_3 = -C_k(x_3^*(\mathbf{k},3) \mid k_3),$$

because the trading surplus that suppliers 1 and 2 generate without supplier 3 is unaffected by the investment in the latter, i.e. $\tilde{TS}_{-3}((k_1,k_2),2)/dk_3 = 0$, and, therefore, supplier 3 obtains the direct gains from the investment. Different from an equilibrium where all of the suppliers offer latent contracts, now the change in the equilibrium payoffs of suppliers 1 and 2 is unaffected by the investment in supplier 3, i.e.:

$$d\pi_i(\mathbf{k},3)/dk_3 = dTS^*(\mathbf{k},3)/dk_3 - d\tilde{TS}_{-i}(\mathbf{k},2)/dk_3 = 0, \text{ for } i = 1,2,$$

because $dTS^*(\mathbf{k},3)/dk_3 = d\tilde{TS}_{-i}(\mathbf{k},2)/dk_3 = -C_k(x_3^*(\mathbf{k},3) \mid k_3)$. Moreover, because supplier 3 does not offer latent contracts, the investment to supplier 3 does not increase the buyers bargaining position with respect to competing suppliers. The buyer does not receive any gains from trade as a result of its investment in supplier 3. We later demonstrate that in any equilibrium where a subset of suppliers do not offer latent contracts, the buyer does not invest in them (see Corollary 3).

We proceed to show that in an equilibrium where supplier 3 does not submit latent contracts, any other supplier may obtain more than the direct gains from investment. To see this, consider an increase in investment in supplier 1. Now, the payoff of supplier 1 is affected by the reallocation of trade of the investment, i.e. $dx_3^*(\mathbf{k},3)/dk_1$:

$$\begin{aligned} d\pi_1(\mathbf{k},3)/dk_1 &= dTS^*(\mathbf{k},3)/dk_1 - d\tilde{TS}_{-1}(\mathbf{k},2)/dk_1 \\ &= -C_k(x_1^*(\mathbf{k},3) \mid k_1) - [U_x(x_3^*(\mathbf{k},3) + \tilde{x}_2(\mathbf{k},2)) - C_x(x_3^*(\mathbf{k},3))] \times \frac{dx_3^*(\mathbf{k},3)}{dk_1}, \\ &= \underbrace{-C_k(x_1^*(\mathbf{k},3) \mid k_1)}_{\text{Direct gain of investment}} \underbrace{- [U_x(x_3^*(\mathbf{k},3) + \tilde{x}_2(\mathbf{k},2)) - U_x(X^*(\mathbf{k},3))] \times \frac{dx_3^*(\mathbf{k},3)}{dk_1}}_{\textit{Increase in supplier's bargaining position}}, \end{aligned}$$

where the last line comes from the equilibrium condition $U_x(X^*(\mathbf{k},3)) = C_x(x_3^*(\mathbf{k},3))$. From Lemma 2 and the regularity conditions, the expression in the brackets is positive and, because $dx_3^*(\mathbf{k},3)/dk_1 < 0$, the second part of the expression is positive. Accordingly, supplier 1 is able to increase its bargaining position and appropriates more than the direct gains from the investment.

The increase in supplier 1's bargaining position emerges because the gains from trade without supplier 1, $\tilde{TS}_{-1}(\mathbf{k}, 2)$, depend on its intensity of investment; supplier 3 offers only the contract that is accepted in equilibrium when the buyer trades with all of the suppliers, which is affected by the vector of investment (see Lemma 1). The increase in investment in supplier 1 generates a reduction in the equilibrium allocation of supplier 3, and the buyer's outside option with a relationship breakdown with 1 decreases. Therefore, supplier 1 becomes more indispensable to the buyer and the supplier's bargaining position increases.

The changes in the equilibrium payoff of the rival suppliers as a result of the investment in supplier 1 are:

$$\begin{aligned} d\pi_3(\mathbf{k}, 3)/dk_1 &= dTS^*(\mathbf{k}, 3)/dk_1 - d\tilde{TS}_{-3}(\mathbf{k}, 2)/dk_1 \\ &= \underbrace{-C_k(x_1^*(\mathbf{k}, 3) \mid k_1) + C_k(\tilde{x}_1(\mathbf{k}, 2) \mid k_1)}_{\textit{Decrease in supplier's bargaining position}}, \end{aligned}$$

and:

$$\begin{aligned} d\pi_2(\mathbf{k}, 3)/dk_1 &= dTS^*(\mathbf{k}, 3)/dk_1 - d\tilde{TS}_{-2}(\mathbf{k}, 2)/dk_1 \\ &= \underbrace{-C_k(x_1^*(\mathbf{k}, 3) \mid k_1) + C_k(\tilde{x}_1(\mathbf{k}, 2) \mid k_1)}_{\textit{Decrease in supplier's bargaining position}} \\ &\quad - \underbrace{\left[U_x\left(x_3^*(\mathbf{k}, 3) + \tilde{x}_1(\mathbf{k}, 2)\right) - U_x(X^*(\mathbf{k}, 3))\right] \times \frac{dx_3^*(\mathbf{k}, 3)}{dk_1}}_{\textit{Increase in supplier's bargaining position}}, \end{aligned} \tag{3.7}$$

for suppliers 3 and 2, respectively.

The investment by supplier 1 reduces the equilibrium payoff of supplier 3. Supplier 1 offers a latent contract that takes into account the relationship breakdown of supplier 3. More investment makes the substitution of the loss of trade from supplier 3 less costly, and supplier 3 becomes less essential to the buyer. As a result, the buyer's bargaining position against supplier 3 increases as it will have a better outside option if a relationship breakdown with this supplier were to occur. The investment in supplier 1 also generates the same reduction in the bargaining position for supplier 2 (see the second line in Expression (3.7)). However, the reduction in the equilibrium trade for supplier 3 also generates an increase in the bargaining position for supplier 2 in a similar way to that of the increase in supplier 1's bargaining position; a lower trade with supplier 3, as a result of the investment in supplier 1, constrains the buyer's outside option with a relationship breakdown with supplier 2. Similar results emerge when calculating the effect generated by the investment in supplier 2.

While the reduction in the bargaining position of competing suppliers is crucial to provide incentives for the buyer to invest, the increase in the bargaining position of the supplier who receives the investment moves in the opposite direction. We proceed to analyze which of the two effects dominates and under which conditions the buyer decides to establish relationship-specific investment. To that end, we begin with a situation where there is no investment and calculate the impact of an increase in investment on the buyer's equilibrium payoff. We now study a more general case with N suppliers. The equilibrium that we select is one where the set of suppliers $J \subseteq N$ does submit latent contracts and the complementary set J^c does not.

Beginning with no investment, i.e. $\mathbf{k} = (0, 0, ..., 0)$, the change in the buyer's equilibrium payoff, net of investment cost, as a result of a positive level of relationship-specific investment with one of the suppliers in $j \in J$ is:

$$\begin{aligned}
\frac{\partial \Pi(N,J)}{\partial k_j} &= \sum_{N \backslash \{j\}} \left[C_k(x_j^* \mid k_j) - C_k(\tilde{x}_j \mid k_j) \right] \\
&\quad + \sum_{J} \left(\sum_{l \in J^c} \left[\left(U_x \left(X^*_{-\{J,j\}} + \sum_{j' \in J \backslash \{j\}} \tilde{x}_{j'} \right) - C_x(x_l^*) \right) \times \frac{dx_l^*}{dk_j} \right] \right), \\
&= \underbrace{\sum_{N \backslash \{j\}} \left(\int_{\tilde{x}_j}^{x_j^*} C_{xk}(\tau) d\tau \right)}_{\textit{Increase in buyer's bargaining position}} + \underbrace{\sum_{J} \left(- \sum_{l \in J^c} \left[\left(\int_{X^*_{-\{J,j\}} + \sum_{j' \in J \backslash \{j\}} \tilde{x}_{j'}}^{X^*} U_{xx}(\tau) d\tau \right) \frac{dx_l^*}{dk_j} \right] \right)}_{\textit{Decrease in buyer's bargaining position}}.
\end{aligned} \tag{3.8}$$

The last line comes from the fundamental theorem of calculus in conjunction with the equilibrium condition that $U_x(X^*) = C_x(x_l^*)$ for all $l \in J^c$. From assumption $U_{xx}(\cdot) < 0$ and Lemma 2, the integral is negative and, because $dx_l^*/dk_j < 0$, the element inside the bracket is positive. The negative sign at the beginning of the expression generates a decrease in the buyer's equilibrium payoff as a result of a decrease in its bargaining position. From the expression, the buyer's equilibrium payoff rises, with a relationship-specific investment, if the increase in its bargaining position (resulting from a larger outside option with competing suppliers) dominates the decrease in its bargaining position (as a result of the trade reallocation from those suppliers who do not offer latent contracts). Therefore, understanding trade reallocation, or allocative sensitivity, dx_l^*/dk_j is crucial in determining which effect dominates. When the allocative sensitivity is sufficiently large, the buyer decides not to invest.

With this analysis and depending on the number of suppliers and the equilibrium in the trading game, the next proposition establishes the buyer's equilibrium investment.

Proposition 2. *With $N < 2$ suppliers, the buyer does not invest.*
With $N \geq 2$ suppliers:

i) With $N = 2$ or $N > 2$ and an "N-equilibrium", the equilibrium investment of the buyer is:

$$\phi_K(K) = \underbrace{- \sum_{j \in N \backslash \{i\}} \left[\int_{x_i^*(\mathbf{k}, N)}^{\tilde{x}_i(\mathbf{k}_{-j}, N \backslash \{j\})} C_{xk}(\tau) d\tau \right]}_{\textit{Increase in buyer's bargaining position}}, \quad \forall i \in N. \tag{3.9}$$

ii) With $N > 2$, in a "J-equilibrium" with $J \subset N$:

iia) for a sufficiently small "allocative sensitivity", the equilibrium investment of the buyer is

$$\phi_K(K) = -\underbrace{\sum_{N\setminus\{j\}}\left(\int_{x_j^*(\mathbf{k},N)}^{\tilde{x}_j(\mathbf{k}|J)} C_{xk}(\tau)d\tau\right)}_{\text{Increase in buyer's bargaining position}} \\ + \underbrace{\sum_{J}\left(-\sum_{l\in J^c}\left[\left(\int_{X^*_{-\{J,j\}}(\mathbf{k},N)+\sum_{j'\in J\setminus\{j\}}\tilde{x}_{j'}(\mathbf{k}|J)}^{X^*(\mathbf{k},N)} U_{xx}(\tau)d\tau\right)\frac{dx_l^*(\mathbf{k},N)}{dk_j}\right]\right)}_{\text{Decrease in buyer's bargaining position}}, \ \forall j \in J. \tag{3.10}$$

iib) Otherwise, the buyer decides not to invest.

The buyer's decision to invest depends on three factors: the number of suppliers, the competition in the trading game and the allocative sensitivity.[21] Without competition in the trading game, investment does not materialize; the supplier appropriates all the gains from the investment and the buyer is entirely held-up. With more suppliers, the competition among them increases the buyer's bargaining position, which may provide incentives to invest. The buyer's investment decisions, however, depend on the competition in the trading game. When the competition is structured such that all suppliers submit latent contracts, the buyer always invests. The most a supplier appropriates are the direct gains from the investment, and its investment increases the buyer's bargaining position against competing suppliers. Investment improves the buyer's terms of trade, which, in turn, provides incentives to invest. However, in equilibria where a group of suppliers does not offer latent contracts, a supplier appropriates more than the direct gains from the investment. Here, the buyer's bargaining power, with respect to the supplier it invests in, decreases; the trade reallocation (allocative sensitivity) makes it more difficult for the competing suppliers to substitute the trade loss of the invested supplier, and the latter becomes more essential to the buyer. Investment only occurs if the buyer's increase its bargaining position with competing suppliers dominates the reduction in its bargaining position with the supplier it decides to invest in, otherwise investment does not materialize.

Direct from Proposition 2, the next corollary characterizes the equilibrium distribution of investment.

Corollary 3. *In a "J-equilibrium" and with a small enough "allocative sensitivity":*

- The buyer sets the same level of investment for all suppliers $j \in J$ and no investment for suppliers $l \in J^c$.

- If the "allocative sensitivity" is large, the buyer does not invest in any supplier.

[21] Note that the results do not hinge on the cost of investment depending on the total level of $\phi(K)$; an alternative formulation such as an additive form may be $\phi(K) = \sum_{i\in N}\alpha(k_i)$ for $\alpha(k_i)$ increasing and convex in k_i, which will generate similar results.

Because Expressions (3.9) and (3.10) are obtained for any supplier that submits latent contracts, the buyer sets the same investment level for each of the suppliers in J. Additionally, the buyer does not invest in those suppliers who do not submit latent contracts as the latter appropriate the direct gains from the investment and do not constrain the equilibrium payoff from competing suppliers. Also, from this corollary, the result of equal distribution of investment in an equilibrium where all of the suppliers offer latent contracts is reminiscent of the result of Chiesa and Denicolò (2012) in their "truthful equilibrium". They state that in a "truthful equilibrium", if the capacity between suppliers becomes more equal according to the Lorenz dominance criterion, the buyer's equilibrium rent increases. In our model, the buyer not only sets the same level of investment in each supplier but also sets a positive level of investment. In other equilibria of the trading game, the buyer may decide not to invest, which would generate a homogeneous market structure.

Market structure

The previous section characterized the buyer's allocation of investment with a group of competing suppliers. In the model, the buyer's investment shapes the equilibrium market structure.

We have shown that when all suppliers offer latent contracts designed to substitute the trade loss from any supplier, the buyer sets specific investment to all of the suppliers. The common buyer ends up trading with a first-tier group of suppliers with whom it has established relationship-specific investment. There is evidence that big automobile and cycling brands work with a rather homogeneous group of suppliers with similar trading patterns. Our model also predicts situations with a heterogeneous market structure. When only a partial group of all the available suppliers submit latent contracts, the buyer undertakes relationship-specific investment with this group, who become first-tier, and does not invest in others, who thus become second-tier. The information technology industry attests to such a market structure when large first-tier suppliers coexist with smaller second-tier suppliers. In computer manufacturing, Dell buys components from many different suppliers (although HIPRO maintains a dominant position).

4. Efficiency of the equilibrium

With the equilibrium investment allocation, we proceed to study possible inefficiencies. First, we characterize the"efficient investment" allocation i.e. the investment allocation that maximizes the trading surplus minus the investment costs $TS^*(\mathbf{k}, N) - \phi(K)$. Because the previous expression is concave with respect to investment, the first-order condition must be satisfied, and doing so is sufficient to obtain the efficient investment allocation. Differentiating with respect to supplier i's investment gives:

$$U_x\left(\sum_{i\in N} x_i^*(\mathbf{k},N)\right)\times\sum_{j=1}^{N}\frac{\partial x_j^*(\mathbf{k},N)}{\partial k_i}-\sum_{j=1}^{N} C_x\left(x_j^*(\mathbf{k},N)\mid k_j\right)\times\frac{\partial x_j^*(\mathbf{k},N)}{\partial k_i}$$
$$-C_k\left(x_i^*(\mathbf{k},N)\mid k_i\right)-\phi_K(K)\times\frac{\partial K}{\partial k_i}.$$

The first part represents how the increase in investment in supplier i affects the valuation of the buyer through a change in the aggregate trade. The second part illustrates the change in the production cost of suppliers as a consequence, first, of the reallocation of trade between them and, second, of the reduction in the production cost of supplier i as a direct effect of the investment. The change in the buyer's investment cost appears in the last part of the expression. Equating the previous first-order condition to zero and applying the envelope theorem, the efficient investment allocation is $\phi_K(K)=-C_k\left(x_i^*(\mathbf{k},N)\mid k_i\right),\ \forall i\in N$. The buyer's marginal investment cost equals the supplier's marginal reduction in the cost of production. The previous condition also establishes a link between the level of investment and the amount of input supplied. An increase in the amount traded by any supplier i must be responded to with an increase in investment in this supplier, if equality is to be recovered. Because of the convex cost of production and the investments' decreasing returns of scale, it is optimal to set the same level of investment with each supplier. The next proposition states this result.

Proposition 3. *The efficient investment allocation is $k_i(N)=k_{i'}(N)=k^*(N)$ for all $i,i'\in N$.*

Because the buyer sets the same level of investment in each supplier, an ex-post homogeneous market structure emerges from having ex-ante identical suppliers i.e. where all suppliers trade the same input with the buyer. However, if we allow for suppliers to have different production costs, it may be efficient to have ex-post heterogeneous suppliers, i.e. more significant levels of investment may be directed to suppliers who benefit more from it. The suppliers receiving more investment would also trade more with the buyer.

With the efficient allocation of investment, the next corollary identifies inefficiencies arising in equilibrium. Inefficiencies come from unequal investment distribution and its aggregate level. We show that the buyer encounters a hold-up problem, and the equilibrium aggregate investment is lower than the level at which optimal efficiency is achieved.

Corollary 4. *For a given number of active suppliers: (i) the equilibrium investment distribution is efficient only when all suppliers offer latent contracts; and (ii) the aggregate level of investment in equilibrium is lower than efficiency.*

This result complements the findings of the literature on cooperative investment. With cooperative investment, the part of the market that does not bear the cost of investment appropriates the direct gains from the investment. The introduction of competition to one side of the market, however, gives the buyer an incentive to invest. When the buyer establishes investment with a supplier, the buyer increases its bargaining position with respect to competing suppliers and it can appropriate part of the gains from its investment. However, the gains from the trade that the buyer appropriates are lower than the total trading surplus generated by the investment. As a result, the aggregate equilibrium of investment is lower than efficiency. Additionally, investment in a supplier reduces the buyer's bargaining power with the former, and if the increase in the supplier's bargaining position is more significant than the buyer's gain, with respect to competing suppliers, the buyer decides not to invest. In this case, the hold-up problem is the most significant concern.

5. Conclusion

The economics of specialization make relationship-specific investment a growing phenomenon and its analysis is essential to understanding the functioning of market transactions. This article studies a buyer's incentives to invest in a group of suppliers and analyses how relationship-specific investment affects the buyer's outside option in the event of a relationship breakdown. The number of suppliers that offer latent contracts to optimally replace the trade loss of any excluded supplier determines the buyer's outside option of a supply breakdown and shapes its incentives to invest. We have stated that when a small number of suppliers offer such latent contracts, specific-investment may not materialize and, as a result, the hold-up problem becomes a significant concern. To address the hold-up problem, it is not sufficient to introduce competition on one side of the market; the intensity of competition, must also be taken into account. In our model, when all of the suppliers submit latent contracts, the buyer always invests and the hold-up problem is minimized.

Our model shows that the buyer's investment decisions shape the suppliers' market structure. When all suppliers offer latent contracts, the buyer sets the same specific investment to all suppliers. This results in a homogeneous market structure wherein the suppliers have similar trading patterns. The evidence suggests that homogeneous market structures, in which a buyer only trades with first-tier suppliers, are characteristic for large automobile companies and large cycling brands. In markets where not all the suppliers offer latent contracts, the buyer sets different investments for different suppliers. An asymmetric market structure then emerges within which first-tier suppliers coexist with second-tier suppliers. The information technology industry attests to such a market structure. In computer manufacturing, Dell buys components from many different suppliers (with HIPRO holding a dominant position).

Comparing the equilibrium allocation with respect to efficiency, the model reveals that specific-investment is always lower than the level of optimal efficiency. The investment serves to enhance competition among suppliers, but this effect is always of second order compared to the direct gains that the investment generates. The existence of the hold-up problem in a setting with cooperative investment and without ex-ante contracts complements the results of Che and Chung (1999), Che and Hausch (1999), and Hori (2006); however, in my model, the magnitude of the hold-up problem depends on the intensity of competition: we have shown that the buyer has more incentives to invest when a broader set of suppliers offers latent contracts. In a situation with less intense competition (all of the suppliers do not offer latent contracts), investment decreases the buyer's outside option in the event of a relationship breakdown and, consequently, it may decide not to invest. A mild intensity of competition may represent a situation when the hold-up problem is the most severe.

Some interesting elements fall beyond the scope of this article. In what follows, we briefly discuss some variations and extensions of the model.

Supplier's entry. Throughout this article, we have assumed an exogenous number of active suppliers. A complete analysis may consider endogenizing the market structure by considering the suppliers' entry decisions. From the analysis of this paper, for a given buyer's investment decisions, a larger intensity of competition (more suppliers offering latent contracts) reduces the gains from trade that suppliers can appropriate (see Corollary 2). Then, the "smaller slice" effect that competition generates reduces the suppliers' incentives to become active in the market. Therefore, we should expect fewer active suppliers whenever market competition is intense. However, the model has shown that more competition in the trading game is associated with more investment by the buyer. When the buyer invests, the gains from trade increase. Then, with the investment decision of the buyer, we also have to take into account a "bigger cake" effect. As a result, if the gains from trade that suppliers obtain from the investment compensate for the decrease in the proportion that they can appropriate, suppliers may have more incentives to become active if they anticipate fiercer market competition.

Competition between buyers. The current model has studied the incentives of a single buyer to invest. In the model, each supplier only has one buyer to whom it can sell. If that buyer does not buy from him, then the seller would cease to be a supplier. Different results may emerge in markets where many buyers compete for suppliers. If other buyers are lurking in the background to which this supplier could sell, the existence of more options changes the supplier's outside option. Additionally, with many buyers, investment in a supplier may generate positive spillovers for other buyers. Making investment conditional on exclusive trade may be a possibility in this new environment. However, the modeling of a trading game in which suppliers offer a menu of trading contracts to different potential buyers would not allow for straightforward analysis.

Dynamic competition. In the current model, we have considered a static competitive environment. In a dynamic setting, it may be interesting to study how investment directed to suppliers or manufacturers might allow the latter to create their brands and move up the value chain. There is evidence that manufacturers become fierce competitors for large OEM buyers: "Lenovo, founded in 1984 as a distributor in China of equipment made by IBM and other companies, will eventually affix its logo to the PCs" (Arruñada and Vázquez, 2006). Best Buy, Carrefour, Sears, and Walmart are selling electronic products under their brands, thereby diluting the marketing clout of OEMs.

Appendix A. Proofs of lemmas and propositions.

Proof of Lemma 1. We prove the lemma by contradiction. For a given investment allocation $\mathbf{k}$ and number of suppliers N, differentiating the first-order conditions for x_j^* given in (2.4) with respect to k_i, we obtain:

$$U_{xx}(X^*(\mathbf{k},N)) \times \sum_{h=1}^{N} \frac{dx_h^*(\mathbf{k},N)}{dk_i} = C_{xx}(x_j^*(\mathbf{k},N) \mid k_j) \times \frac{dx_j^*(\mathbf{k},N)}{dk_i}. \tag{A.1}$$

Because the left-hand side of the equation is independent of j, we find that all dx_j^*/dk_i have the same sign. Now, suppose also that dx_i^*/dk_i has the same sign. Then, the sum also has the same sign, but since $U_{xx}(\cdot) < 0$ and $C_{xx}(\cdot) > 0$ results in the right-hand side and the left-hand side having different signs, this leads to a contradiction.

Now suppose $dx_i^*/dk_i < 0$. The other signs must therefore be positive. By (A.1), we find $\sum_{h=1}^{N} (dx_h^*/dk_i) < 0$, but the first-order condition for x_i^* differentiated with respect to k_i is:

$$U_{xx}(X^*(\mathbf{k},N)) \times \sum_{h=1}^{N} \frac{dx_h^*(\mathbf{k},N)}{dk_i} = C_{xx}(x_i^*(\mathbf{k},N) \mid k_i) \times \frac{dx_i^*(\mathbf{k},N)}{dk_i} + C_{xk}(x_i^*(\mathbf{k},N) \mid k_i),$$

which would then have a positive left-hand side and a negative right-hand side due to $C_{xk}(\cdot) < 0$, which also leads to a contradiction. Thus, we have proven points (i) and (ii) of (a) in the lemma. Again, by (A.1), point (iii) follows from $\partial X^*/\partial k_i = \sum_{h=1}^{N} (dx_h^*/dk_i)$.

Proof of Lemma 2. We must show that for any $J_i \subset N$, we obtain:

$$X^*(\mathbf{k},N) > X^*_{-\{J_i,i\}}(\mathbf{k},N) + \sum_{j \in J_i} \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i). \tag{A.2}$$

For any investment allocation $\mathbf{k}$ with a set J_i, we know that $\sum_{h \in N \setminus \{J_i,i\}} x_h^*(\mathbf{k},N) = X^*_{-\{J_i,i\}}(\mathbf{k},N)$. Hence, the expression above is equivalent to $\sum_{j \in J_i} x_j^*(\mathbf{k},N) + x_i^*(\mathbf{k},N) > \sum_{j \in J_i} \tilde{x}_j(\mathbf{k}, N \setminus \{i\} \mid J_i)$.

Therefore, since $x_i^*(\mathbf{k},N)>0$ if $\sum_{j\in J_i}\left(x_j^*(\mathbf{k},N)-\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)\right)>0$, expression (A.2) is satisfied. Observe that for a given investment allocation, if the above is true, it must also be true for any $j\in J_i$; hence, $x_j^*(\mathbf{k},N)>\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)$. If the opposite occurs, $x_j^*(\mathbf{k},N)<\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)$; then, from the equilibrium allocation, we have:

$$\begin{aligned}U_x\left(X^*_{-\{J_i,i\}}(\mathbf{k},N)+\sum_{j\in J_i}\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)\right)&=C_x(\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i))\\&>C_x(x_j^*(\mathbf{k},N))=U_x(X^*(\mathbf{k},N)),\end{aligned}$$

and by the concavity of $U(\cdot)$, the claim is proven. The above also implies that for any $j\in J_i$, we have $\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)>x_j^*(\mathbf{k},N)$.

Proof of Corollary 1. For $J'\subset J$, implying that $J_i'\subseteq J_i$ and using the same procedure as in Lemma 2, it can be shown that:

$$X^*_{-\{J_i,i\}}(\mathbf{k},N)+\sum_{j\in J_i}\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)\geq X^*_{-\{J_i',i\}}(\mathbf{k},N)+\sum_{j\in J_i'}\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i'),$$

which allows $\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i')\geq\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)$ to be obtained.

Proof of Lemma 1. The introduction of the equilibrium transfer $T_i^*(\mathbf{k},N\mid J_i)$, from (3.5) into the payoff function in (2.2) gives:

$$\begin{aligned}&\pi_i(\mathbf{k},N\mid J_i)=T_i^*(\mathbf{k},N\mid J_i)-C_i(x_i^*(\mathbf{k},N))\\&=U(X^*(\mathbf{k},N))-U\left(X^*_{-\{J_i,i\}}(\mathbf{k},N)+\sum_{j\in J_i}\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)\right)\\&\quad+\sum_{j\in J_i}\left[C_j(\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i))-C_j(x_j^*(\mathbf{k},N))\right]-C_i(x_i^*(\mathbf{k},N))\\&=U(X^*(\mathbf{k},N))-U\left(X^*_{-\{J_i,i\}}(\mathbf{k},N)+\sum_{j\in J_i}\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)\right)\\&\quad+\sum_{j\in J_i}\left[C_j(\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i))-C_j(x_j^*(\mathbf{k},N))\right]-C_i(x_i^*(\mathbf{k},N))+\sum_{N\setminus\{i\}}\left[C_j(x_j^*(\mathbf{k},N))-C_j(x_j^*(\mathbf{k},N))\right]\\&=\underbrace{U(X^*(\mathbf{k},N))-\sum_{N\setminus\{i\}}C_j(x_j^*(\mathbf{k},N))-C_i(x_i^*(\mathbf{k},N))}_{TS^*(\mathbf{k},N)}\\&\quad-\underbrace{\left[U\left(X^*_{-\{J_i,i\}}(\mathbf{k},N)+\sum_{j\in J_i}\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)\right)-\sum_{j\in J_i}C_j(\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i))-\sum_{N\setminus\{J_i,i\}}C_j(x_j^*(\mathbf{k},N))\right]}_{\tilde{TS}_{-i}(\mathbf{k},N\setminus\{i\}\mid J_i)}\end{aligned}$$

for any supplier i, which gives $\pi_i(\mathbf{k},N\mid J_i)=TS^*(\mathbf{k},N)-\tilde{TS}_{-i}(\mathbf{k},N\setminus\{i\}\mid J_i)$.

The buyer's payoff is:

$$
\begin{aligned}
&\Pi(\mathbf{k},N\mid J)=U(X^*(\mathbf{k},N))-\sum_{i\in N}T_i^*(\mathbf{k},N\mid J_i)-\phi(K)\\
&=U(X^*(\mathbf{k},N))-\sum_{i\in N}\left[U(X^*(\mathbf{k},N))-U\left(X^*_{-\{J_i,i\}}(\mathbf{k},N)+\sum_{j\in J_i}\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i)\right)\right]\\
&\quad-\sum_{i\in N}\left[\sum_{j\in J_i}\left[C_j(\tilde{x}_j(\mathbf{k},N\setminus\{i\}\mid J_i))-C_j(x_j^*(\mathbf{k},N))\right]-\sum_{j\in N}\left[C_j(x_j^*(\mathbf{k},N))-C_j(x_j^*(\mathbf{k},N))\right]\right]-\phi(K)\\
&=TS^*(\mathbf{k},N)-\sum_{i\in N}\left(TS^*(\mathbf{k},N)-\tilde{TS}_{-i}(\mathbf{k},N\setminus\{i\}\mid J_i)\right)-\phi(K).
\end{aligned}
$$

Proof of Corollary 2. To show that the equilibrium payoff for a particular supplier i does not increase with the number of suppliers in the set J_i, take any $J_i'\subset J_i$, because for the same investment allocation and N suppliers $TS^*(\mathbf{k},N\mid J_i')=TS^*(\mathbf{k},N\mid J_i)$, then $\pi_i(\mathbf{k},N\mid J_i')>\pi_i(\mathbf{k},N\mid J_i)$ if $\tilde{TS}_{-i}(\mathbf{k},N\setminus\{i\}\mid J_i)>\tilde{TS}_{-i}(\mathbf{k},N\setminus\{i\}\mid J_i')$. Therefore,

$$
\begin{aligned}
\tilde{TS}_{-i}(\mathbf{k},N\setminus\{i\}\mid J_i)&=U\left(X^*_{-\{J_i,i\}}(\mathbf{k},N)+\sum_{j\in J_i}\tilde{x}_j(\mathbf{k},N\setminus\{i\})\right)-\sum_{j\in J_i}C_j(\tilde{x}_j(\mathbf{k},N\setminus\{i\})\mid k_j)\\
&\quad-\sum_{l\in N\setminus\{J_i,i\}}C_l(x_l^*(\mathbf{k},N)\mid k_l)\\
&>U\left(X^*_{-\{J_i',i\}}(\mathbf{k},N)+\sum_{j\in J_i'}\tilde{x}_j(\mathbf{k},N\setminus\{i\})\right)-\sum_{j\in J_i'}C_j(\tilde{x}_j(\mathbf{k},N\setminus\{i\})\mid k_j)\\
&\quad-\sum_{j\in J_i\setminus\{J_i'\}}C_j(x_j^*(\mathbf{k},N)\mid k_j)-\sum_{l\in N\setminus\{J_i,i\}}C_l(x_l^*(\mathbf{k},N)\mid k_l)\\
&=\tilde{TS}_{-i}(\mathbf{k},N\setminus\{i\}\mid J_i')
\end{aligned}
$$

where the inequality comes from expression (3.1).

Proof of Proposition 2. We proceed to calculate the buyer's equilibrium investment for a different number of suppliers:

$N<2$: We have shown in the main text that the buyer decides not to invest. The single supplier obtains all the gains from the investment.

$N=2$: The unique equilibrium of the trading game is when all of the suppliers offer latent contracts (see Proposition 2 in Chiesa and Denicolò, 2009), and the buyer's equilibrium investment is obtained by the solution of the first order-condition

$$\begin{aligned}\frac{\partial \Pi(\mathbf{k},N)}{\partial k_i} &= -C_k\left(x_i^*(\mathbf{k},N)\mid k_i\right) - \left[-C_k\left(x_i^*(\mathbf{k},N)\mid k_i\right)\right] \\ &\qquad - \sum_{j\in N\setminus\{i\}}\left[-C_k\left(x_i^*(\mathbf{k},N)\mid k_i\right) + C_k\left(\tilde{x}_i(\mathbf{k}_{-j},N\setminus\{j\})\mid k_i\right)\right] - \phi_K(K)\times\frac{\partial K}{\partial k_i} = 0 \\ &\implies \phi_K(K) = -\sum_{j\in N\setminus\{i\}}\left[\int_{x_i^*(\mathbf{k},N)}^{\tilde{x}_i(\mathbf{k}_{-j},N\setminus\{j\})} C_{xk}(\tau)d\tau\right],\ \forall i\in N,\end{aligned} \tag{A.3}$$

where the last line comes from the fundamental theorem of calculus.

$N>2$: The buyer's equilibrium investment depends on the extent of competition in the trading game. When all of the suppliers offer latent contracts, the equilibrium investment coincides with expression (A.3).

In an equilibrium in the trading game in which a set of suppliers J^c do not offer latent contracts. The buyer's equilibrium investment to those suppliers $j\in J$ who offer latent contracts is by:

$$\begin{aligned}\phi_K(K) = &-\underbrace{\sum_{N\setminus\{j\}}\left(\int_{x_j^*(\mathbf{k},N)}^{\tilde{x}_j(\mathbf{k}|J)} C_{xk}(\tau)d\tau\right)}_{\textit{Increase in buyer's bargaining position}} \\ &+\underbrace{\sum_{J}\left(-\sum_{l\in J^c}\left[\left(\left(\int_{X^*_{-\{J,j\}}(\mathbf{k},N)+\sum_{j'\in J\setminus\{j\}}\tilde{x}_{j'}(\mathbf{k}|J)}^{X^*(\mathbf{k},N)} U_{xx}(\tau)d\tau\right)\frac{dx_l^*(\mathbf{k},N)}{dk_j}\right]\right)\right)}_{\textit{Decrease in buyer's bargaining position}},\ \forall j\in J.\end{aligned}$$

whenever the allocative sensitivity $dx_l^*(\mathbf{k},N)/dk_j$ is small enough such that an interior solution exists. If the allocative sensitivity is too large, there is a corner solution and the buyer does not invest.

Proof of Proposition 3. To show that a symmetric allocation of investment is optimal, i.e. $k_i = k_{i'} = k$ for all $i,i'\in N$, consider an asymmetric allocation such that $k_1' = k+\Delta k$, $k_2' = k-\Delta k$, and $k_j' = k$ for $j\in N\setminus\{1,2\}$. Assume a reallocation of investment such that the total amount of trade remains constant and that the loss of trade from supplier 2, due to a lower level of investment, is compensated by the increase in trade from supplier 1, who now enjoys a larger investment. Then, this asymmetric investment allocation will only reduce the gain from trade, compared to the symmetric allocation, if the same amount of trade is more costly to produce. From Lemma 1, we know that $x_1^*\left(\mathbf{k}',N\right)\mid k_1') > x_1^*\left(\mathbf{k},N\right)\mid k_1)$ and $x_2^*\left(\mathbf{k}',N\right)\mid k_2') < x_2^*\left(\mathbf{k},N\right)\mid k_2)$. Then, applying the fundamental theorem of calculus, the difference in the production cost becomes:

$$\int_{x_1^*(\mathbf{k},N)|k_1}^{x_1^*\left(\mathbf{k}',N\right)|k_1'} C_{xk}(\cdot) + \int_{x_2^*\left(\mathbf{k}',N\right)|k_2'}^{x_2^*(\mathbf{k},N)|k_2} C_{xk}(\cdot) < 0,$$

and is always negative due to assumption $C_{xk}(\cdot) < 0$. The total cost of production is larger with an asymmetric allocation of investment. Therefore, the buyer decides to reallocate investment until the same investment is set to all suppliers. This strategy minimizes the total cost of production.

Proof of Corollary 4. With N suppliers, we compare the equilibrium investment, characterized in proposition 2, against efficiency. In the equilibrium scenario, where all of the suppliers offer latent contracts, the efficient investment will be larger than that in the equilibrium if the right-hand side for the expression that characterizes investment is:

$$
\begin{aligned}
&-C_k\left(x_i^*(\mathbf{k},N) \mid k_i\right) > -\sum_{j\in N\setminus\{i\}}\left[\int_{x_i^*(\mathbf{k},N)}^{\tilde{x}_i(\mathbf{k}_{-j},N\setminus\{j\})} C_{xk}(\tau)d\tau\right] \\
&\quad\Longrightarrow \sum_{j\in N\setminus\{i\}}\left[C_k\left(\tilde{x}_i(\mathbf{k}_{-j},N\setminus\{j\}) \mid k_i\right) - C_k\left(x_i^*(\mathbf{k},N) \mid k_i\right)\right] - C_k\left(x_i^*(\mathbf{k},N) \mid k_i\right) > 0 \\
&\quad\Longrightarrow \int_{X^*(\mathbf{k},N)}^{(N-1)\times\tilde{x}_i(\mathbf{k}_{-j},N\setminus\{j\})} C_{xk}(\tau)d\tau > 0.
\end{aligned}
$$

Both lines come from the fundamental theorem of calculus and the last line is positive due to assumption $C_{xk}(\cdot) < 0$ and lemma 2, which shows that $X^*(\mathbf{k},N) > (N-1)\times\tilde{x}_i(\mathbf{k}_{-j},N\setminus\{j\})$.

The same analysis also shows that in equilibria, where a set of suppliers do not offer latent contracts, the increase in the buyer's bargaining position represented in the first part of the right-hand side of Expression (3.9) is lower than the efficient investment represented in the right-hand side. Additionally, in those equilibria, the buyer's bargaining position with the suppliers it invests in decreases, which reinforces the result that the efficient level of investment is larger.

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