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RESEARCH ARTICLE

Contracting to (dis)incentivize? An integrative transaction-cost approach on how contracts govern specific investments

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Abstract

Research Summary: Buyer–supplier collaborations are plagued by multiple frictions—haggling, non-contractible adaptation, and resource appropriation. This article examines how contracts govern relationship-specific investment in the face of these frictions. In our model, investment increases the value the supplier creates for the buyer ex post by adapting a component to her needs. At the same time, specific investment exposes the supplier to haggling, while providing him with knowledge needed to appropriate the buyer's preexisting resources. By muting both haggling and adaptation incentives, "closed price" contracts elicit higher investment than "open price" contracts when adaptation is unimportant, and lower investment otherwise. Moreover, an optimal price format seeks to incentivize investment when resource appropriation is unimportant, and to disincentivize investment otherwise. Our evidence on component procurement contracts supports both predictions.

Managerial Summary: This study offers new insights on how OEMs govern their collaborations with suppliers. We examine settings where the supplier invests in producing a dedicated component, and ask under which contractual form she is more/less motivated to invest. We find that "closed price" contracts decrease supplier's investment when the component has a complex interface with the OEM's product, and hence is more subject to post-contractual adaptation. We also find that OEMs choose the contract that *discourages* investment when they possess unique resources that too-closely-involved suppliers may copy or appropriate. Managers at OEMs that possess proprietary technologies and customer bases are exposed to the appropriation downside of suppliers' dedicated investment, and will thus benefit from learning through our study how other professionals address this issue.

KEYWORDS

adaptation, contract, governance, price format, specific investments, transaction cost economics

1 | INTRODUCTION

A prime goal of strategic management is understanding the drivers of value creation in collaborative interfirm relationships. One of the major paradigms developed to pursue this endeavor is transaction cost economics (TCE), which emphasizes relationship-specific investments as a key determinant of value creation, warns that these investments may also expose firms to contractual hazards, and calls for appropriate governance structures to safeguard against such hazards (e.g., Masten, 1988; Williamson, 1979).

The link between specific investment and governance has received strong support in TCE-inspired empirical research (e.g., Macher & Richman, 2008). However, because this research focuses on asset specificity as an exogenous determinant of governance, it provides limited insight on how governance affects the endogenous choice of specific investment in interfirm collaborations, and which governance forms *induce* desired specific investments in the face of contracting frictions.

We seek to fill this gap in our paper and show, both theoretically and empirically, how firms design governance structures—in our case, contract forms—to optimally induce or dis-incentivize specific investments in buyer–supplier relationships. To do so, we develop a theoretical model that incorporates three key contracting frictions emphasized by TCE—namely, costly haggling (e.g., Klein, Crawford, & Alchian, 1978), non-contractible adaptation (e.g., Williamson, 1991), and the risk of appropriation of firm-specific resources that preexist the relationship (Teece, 1986; Oxley, 1997, 1999; Ghosh & John, 2005). Unlike previous TCE models that study these frictions in isolation (e.g., Bajari & Tadelis, 2001; Gibbons, 2005; Masten, 1988), we explicitly look at how suppliers' choice of specific investment jointly affects haggling, non-contractible adaptation, and resource appropriation. Our model generates testable predictions on how the relative importance of the three frictions affects the equilibrium level of specific investment under different contract forms, and the optimal choice of contract form. We empirically test the predictions from our integrative model using proprietary data on procurement contracts for engineered components between OEMs and their component suppliers, and find robust support for all of them.

In our model, an OEM (she) contracts with a supplier (he) who may invest in the production of a dedicated component. At the beginning of their relationship, the two parties choose between two alternative price formats that are typically observed in OEM-supplier contracts: "closed price," which specifies the component's price before the supplier makes a relationship-specific investment, and "open price," which allows for the price to be negotiated after the investment is made (e.g., Crocker & Reynolds, 1993). After the contract form is chosen, the supplier makes a non-contractible, relationship-specific investment that customizes the component to the OEM and creates value for her in the downstream customer market (e.g., Hart & Moore, 1988).

The key insight from our model is that the three contracting frictions of haggling, adaptation, and resource appropriation are jointly affected by the supplier's specific investment, as follows. Once the supplier invests, he may face an unforeseen opportunity to further improve the component by taking a non-contractible "adaptation" action (e.g., Gibbons, 2005). The higher the component's baseline value created by specific investment, the higher the value-add of adaptation. This value-creating benefit is counterbalanced by two potential downsides of specific investment. First, as emphasized in TCE, specific investment locks the supplier and the OEM into a bilateral monopoly; as a result, the OEM may engage in opportunistic "haggling" over the component's price (e.g., Hart & Moore, 2008; Masten, 1986, 1988). Second, as highlighted by recent theoretical models (Zanarone, Lo, & Madsen, 2016), specific investment may enable the supplier to appropriate preexisting resources that the OEM brings to the relationship. For instance, the supplier may use knowledge of the OEM's technology gained while customizing the component to compete with the OEM in the end-product market (Alcacer & Oxley, 2014; Arruñada & Vazquez, 2006) or develop components for competing OEMs. The supplier may also use his acquired knowledge of the OEM's operations to shirk on the component's quality without formally breaching his contract with the OEM.

Our model generates two novel results, neither of which would arise if the haggling, adaptation, and appropriation frictions were studied in isolation and/or in the absence of specific investment, as in standard TCE models. First, we show that the effect of contracts on specific investment is not uniform, and depends on the tradeoff between adaptation benefits and haggling costs that such investment generates. On the one hand, haggling costs reduce the supplier's incentive to invest under an open price, relative to the closed price, because specific investment increases the supplier's exposure to haggling. On the other hand, adaptation benefits increase the supplier's incentive to invest under an open price, relative to the closed price, because the open price allows the supplier to bargain over the value created by adaptation and to appropriate a share of such value. Thus, holding the potential haggling costs constant, an open price format increases the supplier's specific investment when adaptation is important, and decreases it otherwise.

Second, we show that concerns over appropriation of preexisting resources determine whether contracts are chosen to incentivize or *disincentivize* the supplier's specific investment. In particular, our model suggests that the more valuable the OEM's preexisting resources, the higher the supplier's return on making a specific investment that may later enable him to appropriate such resources. Hence, when the value of the OEM's preexisting resources is high enough, the supplier will overinvest, and the optimal price format will be the one that reduces his incentives to invest—that is, a closed price when adaptation is important enough, and an open price otherwise.

We test our model's predictions using proprietary survey data on 155 procurement contracts for engineered components between OEMs and suppliers in the U.S. Controlling for the endogenous choice of price formats, we find that a closed price contract decreases the supplier's specific investment when adaptation is important, and increases it otherwise. Second, we find that the effect of adaptation on contract choice is moderated by the OEM's resource appropriation concerns. Specifically, when adaptation is important, the likelihood of choosing an investment-reducing closed price contract increases when the OEM's preexisting resources have high value, and decreases when they have low value.

Altogether, our model and empirical results confirm the validity of TCE, with its focus on holdup, haggling costs, and non-contractible adaptation, as a framework to understand the role of contracts in governing interfirm collaborations in the presence of specific investments. At the same time, our analysis suggests that formal TCE models, which consider contracting frictions in isolation and pay limited attention to how specific investment endogenously affects them, miss important channels through which contracts govern interfirm relationships. We show that the tradeoff between haggling and adaptation defines distinctive "regions" in which a closed price contract (low adaptation region) or an open price contract (high adaptation region) maximizes the supplier's specific investment. Moreover, the OEM's desire to protect preexisting resources results in a complex "strategizing calculus" (e.g., Ghosh & John, 1999, 2005) where governance may counterintuitively *disincentivize* investments in order to prevent resource appropriation.

2 | LITERATURE REVIEW

Our paper relates to a vast empirical literature in strategy and industrial organization that examines contracts, and particularly pricing formats, as mechanisms to govern interfirm collaborations. We discuss below some studies that are more closely related to TCE and to our work, while referring readers interested in a more comprehensive discussion to the excellent reviews by Macher and Richman (2008), Lafontaine and Slade (2013), and others.

Early TCE studies have focused on how asset specificity, bilateral monopoly, and the importance of adaptation, affect contract design. Joskow (1987) finds that electric utilities enter longer-term formal agreements with coal suppliers to whom they are closely located. Masten and Crocker (1985) find that gas suppliers are more likely to be protected by take-or-pay provisions in their relationships with pipelines when their gas is less valuable if put to alternative uses. More related to our study, Crocker and Masten (1991) find that to facilitate adaptation, contracts of longer duration are more likely to contain open price provisions. Crocker and Reynolds (1993) find that Air Force engine procurement contracts are more likely to include closed price terms when the contractor has a history of litigiousness (a proxy for haggling costs) and when the environment is less uncertain, such that pricing provisions are unlikely to be renegotiated. More recent studies have expanded the TCE framework to explore additional determinants of contract choice, such as repeated interaction (Corts & Singh, 2004; Kalnins & Mayer, 2004). Closer to our paper, Lo, Frias, and Ghosh (2012) investigate the impact of an OEM's preexisting resources on the choice of pricing formats in co-branding agreements. They find that consistent with the importance of resource appropriation concerns, closed price formats are more likely to be chosen when the supplier's product is differentiated but not customized to the OEM and when the OEM has higher market strength.

Our paper innovates on this empirical literature in two ways. First, it provides (to the best of our knowledge) the first investigation of how contractual price terms govern and shape suppliers' incentives to undertake specific investments. While a few theoretical works in TCE have pointed out and investigated the endogeneity of specific investments (e.g., Jia, 2013; Riordan & Williamson, 1985), TCE-inspired empirical studies have predominantly focused on how exogenous variations in asset specificity affect contract choice and governance. A few empirical works in strategy investigate the determinants of specific investments and how these affect performance (e.g., Argyres & Bigelow, 2010; Bensaou & Anderson, 1999; Nickerson, Hamilton, & Wada, 2001; Nickerson, Hamilton, Wada, & Silverman, 2003). However, none of these articles study how specific investments are affected by contractual governance. Second, while existing studies have separately analyzed how haggling costs and adaptation frictions affect contract choice, our paper provides evidence that the direction of such effects depends on the *interaction* of these two frictions, both with each other and with resource appropriation.

Our paper also contributes to the formal theoretical literature on incomplete contracts. One stream, pioneered by Hart, has analyzed how asset ownership and contract design affect the incentive to undertake non-contractible specific investments (e.g., Grossman & Hart, 1986; Hart & Moore, 1988). More recent papers in this stream have modeled the effect of contracts and ownership on adaptation to unforeseen contingencies rather than on specific investments. These papers have alternatively modeled adaptation as unilateral non-contractible actions (Gibbons, 2005; Hart, Schleifer, & Vishny, 1997) or as project renegotiations that may fail due to informational asymmetries (Bajari & Tadelis, 2001). Another stream has formalized the "haggling" costs described by Klein et al. (1978). For instance, Masten (1986) and Gibbons (2005) have modeled costly haggling as the waste of time and resources in rent-seeking activities, while Masten (1988) has modeled post-contractual "jockeying," a form of rent-seeking behavior that directly harm one's counterpart. More recently, Hart and Moore (2008) have formalized haggling costs as "shading," that is, performance reductions that occur when parties are dissatisfied with the outcome of contractual negotiations and retaliate against each other. Unlike our paper, none of these studies models the interaction between specific investment, haggling costs, and adaptation frictions. Our paper therefore offers a novel contribution to the formal literature on incomplete contracts by showing that the interaction between haggling costs and adaptation affects how contracts govern specific investments, and hence the determinants of contract choice.

Finally, our results on resource appropriation relate to a small literature that connects TCE with the resource-based view of the firm, which emphasizes the strategic role of heterogeneous, immobile resources possessed by a firm (e.g., Peteraf, 1993; Wernerfelt, 1984). Early research in this stream has recognized that firms possessing preexisting endowments and resources are likely to seek governance structures to mitigate appropriation hazards (e.g., Ghosh & John, 1999; Oxley, 1997). For instance, Oxley (1999) and Oxley and Wada (2009) discuss how the usage of equity-based collaborations and hierarchy—instead of contracts—reduces the scope of expropriation. More recently, Zanarone et al. (2016) have introduced and formally modeled the idea that partner-specific investments facilitate resource appropriation, and that optimal pricing formats induce investment levels that balance the conflicting goals of value creation and resource protection. Lo et al. (2012) provide evidence consistent with this approach. Our paper extends this literature by showing how appropriation concerns interact with the classic frictions analyzed by TCE—haggling and adaptation—in determining contract choice.

3 | MODEL AND HYPOTHESES

In this section, we develop a game-theoretic model of the contractual relationship between an OEM and a component supplier. Our model nests the three key frictions highlighted by TCE scholars—haggling, adaptation, and the appropriation of preexisting resources—and elucidates how these frictions are *simultaneously* affected by the supplier's choice of specific investment under different contractual provisions. We present the model's building blocks, key mechanisms, and results below, while deferring details of the formal analysis and mathematical proofs to Online Appendix A.

3.1 | Setting

There are an OEM (M) and a supplier (S), both of whom are risk-neutral. Prior to entering a contractual relationship with S, M possesses preexisting resources of value ω. This value can be considered as an index of the OEM's differentiation in its end-product market at the time of contracting, which is independent of the relationship between M and S. M may procure from S a "standard" component, whose value to M we normalize to zero for simplicity, or a "customized" component, which adds value to M's end product. S can customize the component by making a relationship-specific investment—that is, undertaking effort to understand M's specific design, technology, and customer needs, and to produce the component accordingly.

3.2 | Timeline

Consistent with industry practice, we organize the timeline of the buyer–supplier collaboration as follows. At Stage 1 (the *contracting stage*), M and S contractually agree on the governance—in our case, the price format—for the component being procured. They either specify the component's price p upfront (i.e., choose a closed-price format) or agree to negotiate it ex post (i.e., choose an open-price format). Following Williamson, we assume contracting at Stage 1 is competitive, in the sense that there are multiple alternative suppliers from which M can buy, and who can provide the same equilibrium specialized quality, and multiple alternative buyers to which S can sell. As a result, the wasteful rent-seeking discussed in the introduction, and modeled below, does not occur at the contract choice stage: facing rent-seeking from the counterpart, each party would immediately switch to an alternative partner.

At Stage 2 (the *investment stage*), S chooses a specific investment, a. S's investment cost, for simplicity, equals the investment level, a. Following recent work in strategy (e.g., Alcacer & Oxley, 2014; Zanarone et al., 2016), we assume that in addition to creating value for the OEM, S's investment also potentially enables S to appropriate M's resources (for instance, by using the knowledge obtained in the relationship to develop components for a competing OEM). We provide precise mathematical definitions of value creation and appropriation below. Moreover, following TCE, we assume that if S makes a specific investment, the relationship between M and S may undergo a "fundamental transformation", in the sense that M and S may be locked into a bilateral monopoly relationship. Formally, we assume the fundamental transformation occurs with probability $\mu(a)$, where $\mu(a)=0$ if $a=0$, and $\mu(a)=1$ if $a>0$.[1]

At Stage 3 (the *adaptation stage*), a state of the world $\sigma \in \{0,1\}$ is realized and observed by both M and S. In the "status quo state" ($\sigma=0$), which occurs with probability $1-\theta$, S's investment generates a customized component of value $q(a)$, assumed to be increasing in the investment level ($q_a>0$) and concave ($q_{aa}<0$). In the "adaptation state" ($\sigma=1$), which occurs with

[1]As shown in the online Appendix A, the model's results would be qualitatively unchanged if we assumed the probability of a fundamental transformation, $\mu(a)$, continuously increases in S's specific investment.

probability θ, S has an opportunity to further improve the component, such that its value to M increases from $q(a)$ to $(1+v)q(a)$. We assume for simplicity that $v=1$. After observing the state, S makes his adaptation decision, $d \in \{0,1\}$, incurring a cost $c>0$ if he improves the component ($d=1$), and no cost if he leaves the component as it is ($d=0$).

At Stage 4 (the *bargaining stage*), if they have chosen the open-price format, M and S bargain over the component's price p. S then delivers the component to M at the agreed upon price. Consistent with the TCE literature (e.g., Klein et al., 1978; Masten, 1988), we allow for wasteful "haggling" to occur at this stage (due to the parties being locked into a bilateral monopoly situation that makes switching to a different partner not viable). Specifically, M and S may take actions that increase their chances to secure the net surplus from the transaction, or "appropriable quasi-rents," at the cost of damaging the counterpart. For instance, M may withhold relevant information, or refuse to provide cooperation that reduces S's performance cost, until S concedes on the price (Crocker & Masten, 1991). Relatedly, M may badmouth S to other OEMs, or refuse to provide S with references.

Following Masten (1986) and Gibbons (2005), we model haggling as a "Tullock contest" (Tullock, 1980) in which both B and S haggle in the hope to "win the prize" (i.e., grab the quasi-rents).[2] Moreover, following Masten (1988), we assume M's (S's) haggling causes a loss $k>0$ to S (M). We assume for simplicity that haggling does not impose a direct cost (e.g., time or out-of-pocket expense) on the rent-seeking party. Similar predictions would obtain if we allowed for such direct cost (so long as it is not prohibitive), or if we allowed for asymmetric haggling losses $k_S \neq k_M$ (so long as $k_S>0$). A more detailed analysis of the haggling contest is in Online Appendix A.

At Stage 5 (the *appropriation stage*), S takes advantage of the specific investment made at Stage 2 to appropriate part of M's preexisting resources. To formalize appropriation in the simplest possible way, we adapt Zanarone et al. (2016) and assume S grabs a share $\beta(a) \in [0,1]$ of the value ω of M's preexisting resources,[3] where $\beta(a)$ is increasing in S's specific investment ($\beta_a>0$) and concave ($\beta_{aa}<0$). Finally, M and S obtain their payoffs as a result of the chosen price format, S's investment, adaptation, haggling, and appropriation.

3.3 | Contractual assumptions

Following the tradition of formal incomplete contracting models (e.g., Grossman & Hart, 1986; Hart & Moore, 1988), we assume that while "trade" (i.e., delivery of a component to M in exchange for a price) is contractible, the need for adaptation, S's specific investment, and whether the component is standard or customized, are observed by M and S but cannot be verified by courts, and are therefore non-contractible. Moreover, we integrate separate streams of the TCE literature and assume that S's adaptation decision (Gibbons, 2005; Williamson, 1991), and haggling and its losses (Gibbons, 2005; Masten, 1988) are also non-contractible.[4] Finally, we follow Zanarone et al. (2016) in assuming that S's appropriation of M's preexisting resources

[2]Similar predictions would obtain under alternative modeling approaches to haggling, such as Hart and Moore (2008).
[3]Results would be identical if appropriation occurred at any other stage after S has invested. Moreover, our results would hold *a fortiori* if the OEM's appropriation loss outweighed the supplier's gains, rather than equaling them.
[4]There is growing evidence that adaptation decisions are too urgent to be negotiated ex post and are therefore driven by the ex ante allocation of decision rights and incentives among firms. See Arruñada, Garicano, and Vazquez (2001), and Zanarone (2013), on franchising; Forbes and Lederman (2009), Gil, Kim, and Zanarone (2021), and Argyres, Gil, and Zanarone (2021), on airline partnerships; and Barron, Gibbons, Gil, and Murphy (2020) on movie distribution.

is non-contractible. Altogether, these assumptions imply that M and S choose all actions noncooperatively given the incentives created by their formal pricing agreement.

3.4 | Discussion of modeling assumptions

A few features of our model deserve further discussion. First, we rule out the possibility of ex post haggling and rent-seeking under a closed price contract. This is clearly a simplification as buyers and sellers do occasionally renegotiate the contractually stipulated price—for instance, if performance becomes onerous for one of the parties (e.g., Crocker & Masten, 1991; Masten, 1988), or if contractible modifications of the product are needed ex post (Bajari & Tadelis, 2001). Allowing for some renegotiation and haggling under a closed price contract would not alter our model's predictions, however, so long as such haggling is less likely to occur than under an open price contract. This is a reasonable assumption: when it cannot be proved that performance has become onerous, and specifications do not need to be changed, renegotiation of a closed price is purely redistributive and thus courts will not enforce it (Schwartz, 1992).

Second, in order to keep the analysis simple, we abstract from governance mechanisms other than price formats that have been analyzed in the literature, such as relational norms (e.g., Heide & John, 1990), self-enforcing agreements (e.g., Baker, Gibbons, & Murphy, 2002), monitoring and control rights (e.g., Arruñada et al., 2001; Zanarone, 2013), hostages (e.g., Anderson & Weitz, 1992; Williamson, 1983), and noncompete covenants (e.g., Garmaise, 2009). We control for many of these auxiliary instruments in our empirical analysis.

Third, we study a model where only S makes a specific investment. While this is a natural representation of OEM-supplier relationships, in principle M may also make specific investments—say, in training S—that may both create value and favor appropriation of the supplier's preexisting resources. It is easy to show that our key results on how price formats affect investment and value are robust to the inclusion of OEM specific investments.

Finally, we assume a specific bargaining protocol (the Tullock model) in our analysis of price negotiation in the open price regime. Our predictions would continue to hold under different bargaining protocols that result in more unequal distributions of the surplus, provided the supplier's "bargaining strength" (i.e., the share of bargaining surplus S can secure) is positive—that is, M is not in the position to make a take-it-or-leave-it offer to S that allows M to extract all the surplus. When S can bargain, he is willing to adapt and invest in the open price regime because he/she shares in the gains from adaptation and investment via bargaining.

3.5 | Choice of specific investment under a closed versus open price format

Using our integrative TCE model, we analyze below how the two alternative contract forms, closed versus open price format, affect S's choice of specific investment. Under a closed-price format, the price is specified ex ante, at Stage 1. This implies that there is no haggling at Stage 4. Moreover, S has no incentive to adapt at Stage 3 because under a closed price contract, S bears the adaptation cost c while M receives all the benefits from adaptation. Anticipating that, at Stage 2, S chooses specific investment to maximize the gains from appropriating part of the buyer's preexisting resources, minus the investment's cost. As a result, S chooses a positive level of specific investment, a^C, which increases in ω, the value M's preexisting resources that the specific investment enables S to appropriate.

Under an open price format, M and S bargain over the price at Stage 4. As in all Tullock contests, both M and S haggle in equilibrium, each receiving half of the quasi-rents minus the haggling loss. At Stage 3 (the adaptation stage), S expects to share in the value of adaptation via bargaining. Thus, assuming the cost is low enough, S is happy to adapt the component as needed. At Stage 2, S anticipates the bargaining and adaptation outcomes, and chooses the investment level that maximizes his expected payoff, that is: half of the quasi-rents, plus the gains from appropriating the buyer's preexisting resources, minus the haggling and investment costs. As in the closed price case, S's investment under the open price increases in the value of M's preexisting resources, ω. Unlike in the closed price case, however, S's return on making a specific investment also increases in the expected need for adaptation θ (because the supplier captures part of the adaptation value through bargaining), and decreases in the haggling cost k (because specific investment increases the probability of lock-in and hence exposes the supplier to haggling). As formally shown in the Appendix, this implies that S's specific investment under the open price increases in θ and decreases in k.

Since the closed price investment does not depend on adaptation or haggling costs, it then follows from our analysis that if the haggling cost is non-extreme (i.e., neither too high nor too low[5]), S will invest more in the open price regime than in the closed price one if the expected need for adaptation is high enough, and vice versa if the need for adaptation is low.

Proposition 1. *There exists a critical cutoff* $\theta^* \in (0,1)$, *such that under a closed price, S's specific investment is higher than under an open price contract* $(a^O < a^C)$ *when adaptation is unimportant* $(\theta \le \theta^*)$, *and lower* $(a^O > a^C)$ *when adaptation is important* $(\theta > \theta^*)$.

Our proposition is illustrated by Figure 1. This result shows that the effect of a formal pricing provision (closed price) on specific investment is ambiguous and depends on the relative importance of the two contractual frictions emphasized by Williamson—haggling costs and adaptation.

Since the component's value-add to M increases in specific investment and adaptation, an immediate corollary of Proposition 1 is that a closed price format increases the component's value-add when adaptation is unimportant, and decreases it when adaptation is important.

Proposition 2. *Under a closed price, S's value-add is higher than under an open price when adaptation is unimportant* $(\theta \le \theta^*)$, *and lower when adaptation is important* $(\theta > \theta^*)$.

3.6 | The effect of appropriation hazards on the choice of price format

Having described specific investment, adaptation, and value-add under the closed price and the open price format, we conclude our theoretical analysis by asking which of the two price

[5]A formal definition of non-extreme haggling costs is provided in online Appendix A.

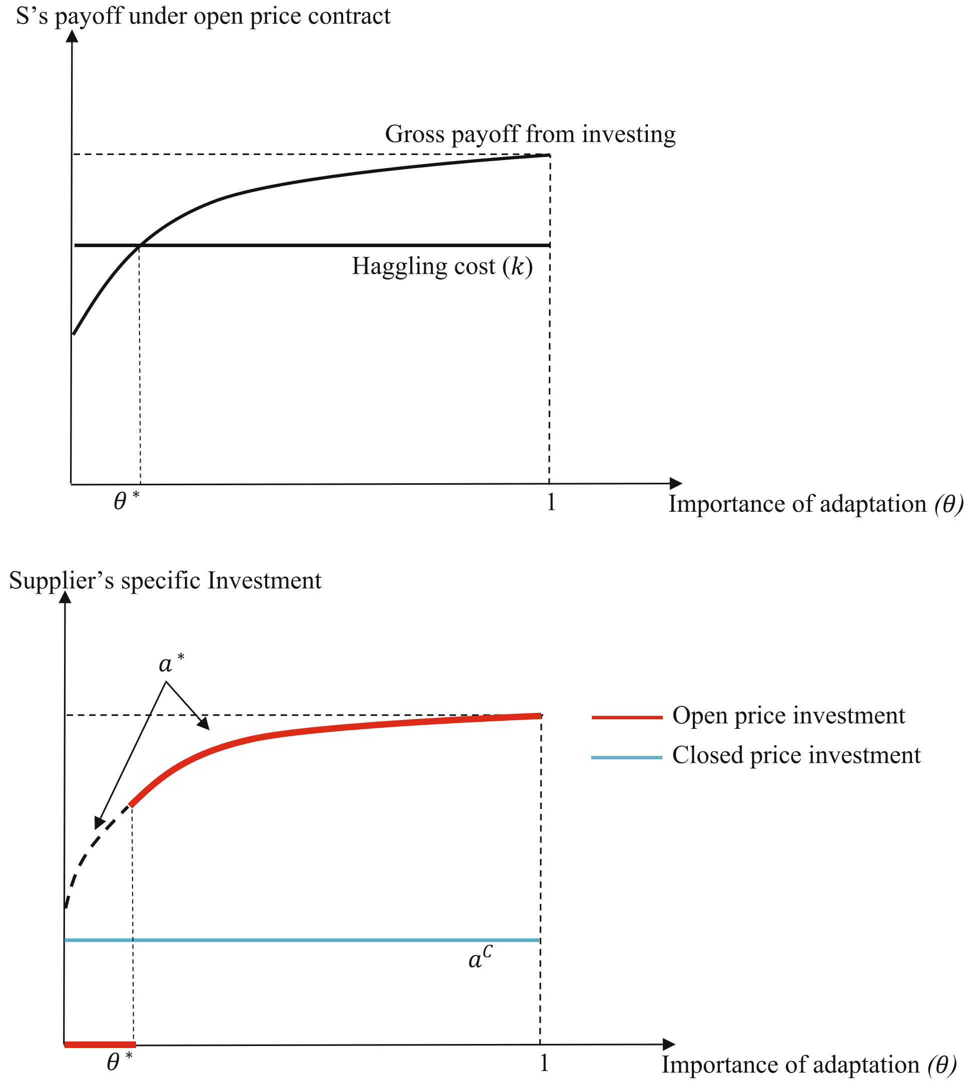

FIGURE 1 Choice of specific investment under open price versus closed price contracts

formats maximizes total value creation (i.e., the sum of M's an S's expected payoffs), and is therefore optimal, under different combinations of contracting frictions.

It turns out the third friction analyzed by our model—S's appropriation of M's preexisting resources—and its interaction with the haggling and adaptation frictions, plays a crucial role in answering this question. Recall that S's investment increases in the value of preexisting resources, ω, under both the closed price and the open price format. When ω is relatively low, appropriation is a minor hazard, and S underinvests (relative to level that maximizes total value) under both contractual forms, due to the haggling and appropriation frictions. In that case, the optimal price format is the one that increases S's incentive to invest—that is, per our Proposition 1, the closed price when adaptation is unimportant, and the open price when adaptation is important. This result is reversed when ω is large, such that appropriation is a substantial hazard. In that case, S *overinvests* under both contractual forms, and the optimal price format is the one that *disincentivizes* S's investment—that is, the closed price when adaptation is important, and the open price when adaptation is unimportant.

Proposition 3. *When adaptation is unimportant* ($\theta \leq \theta^*$)*, there is a critical cutoff* ω^**such that the optimal contract is closed price if the value of M's preexisting resources is low enough* ($\omega < \omega^*$)*, and open price if the value of M's resources is high* ($\omega > \omega^*$)*. When adaptation is important* ($\theta > \theta^*$)*, there is a critical cutoff* ω^{**} *such that the optimal contract is open price if the value of M's preexisting resources is low enough* ($\omega < \omega^{**}$)*, and closed price if the value of M's resources is high* ($\omega > \omega^{**}$)*.*

Proposition 3 shows that incorporating resource appropriation into the TCE framework reverses the role of contracts in governing specific investment. Absent resource appropriation, an optimal contract incentivizes investment in order to increase the value created by the OEM-supplier match. When resource appropriation is important, however, the OEM's key goal is to *mitigate overinvestment*, and as a result, an optimal contract form *disincentivizes* investment at the cost of reducing value creation.

Table 1 summarizes the testable predictions implied by our model's propositions, and their underlying intuition. In the next section, we take these predictions to the data.

4 | DATA AND MEASURES

We test our hypotheses in the context of industrial OEMs procuring engineered components from independent suppliers. We use data from a survey of OEMs in three major industrial sectors of the U.S. economy: nonelectrical machinery (SIC 35), electrical and electronic machinery (SIC 36), and transportation equipment (SIC 37). We first conducted on-site, in-depth interviews with OEM purchasing managers. We used the resulting information to develop a pilot questionnaire that was then administered to purchasing managers at 18 OEMs to verify appropriate wording, response formats, and clarity of the instructions. The final survey was constructed based on their feedback. The unit of analysis is a procurement contract between an OEM and its independent supplier for the supply of a component, or a set of technologically indivisible components integrated into a subsystem, that are physically incorporated into the OEM's end product. "Independent supplier" in our context means a supplier who is not tied to the OEM by cross-equity holdings; thus, joint ventures and other equity arrangements are excluded from our analysis.

The key informant methodology (Campbell, 1955) was used to qualify the informants in the study. These individuals were either purchasing managers or directors in industrial OEMs in the three sectors considered in our study. Multiple telephone calls, five on average, were used to qualify the informant in each firm. Informants were then asked to identify their firm's most important product-line and to identify a procurement agreement with an independent component supplier under which their firm purchased an engineered component or subsystem. To encourage participation, these informants were offered a customized report that summarized the relationship profiles in the sample and compared their own relationship with the average profile in the data. This process yielded a total of 521 informants to whom the questionnaires were mailed. After using reminder

TABLE 1 Summary of the theoretical model

Regions of parameters		Frictions affecting S's investment: Haggling	Adaptation	Resource appropriation	Price term generating higher investment	Problem with investment level	Governance role of price terms	Optimal contract
Low ω	Low θ	•			Closed price	Underinvestment	To increase investment	Closed price
Low ω	High θ		•		Open price	Underinvestment	To increase investment	Open price
High ω	Low θ	•		•	Closed price	Overinvestment	To decrease investment	Open price
High ω	High θ		•	•	Open price	Overinvestment	To decrease investment	Closed price

cards and follow-up telephone calls and removing responses due to excessive missing data, we obtained a final sample of 155 responses.[6]

4.1 | Measures

Table 2 describes the measures in our study and provides summary statistics. Table B1 in our online Appendix B shows their pairwise correlations.

4.1.1 | Price format

This measure describes the pricing provision used in the focal contract to procure the engineered component or subsystem. Our measure is adapted from Crocker and Reynolds (1993), Ghosh and John (2005), and Lo et al. (2012). To match our analytical model, we classified *closed-price formats* as those agreements in which the OEM and the supplier agreed to either a fixed price or a price formula tied to objective, verifiable and exogenous criteria (e.g., inflation in commodity prices, producer price index, etc.). Closed-price formats preclude renegotiation and hence pre-determine the division of trade surplus over the contract period. In contrast, we classified *open-price formats* as those that either did not specify a price ahead of shipment, or did specify a price but allowed for *negotiated* adjustments. Under open-price formats, the distribution of trade surplus is therefore determined ex post. *Price format* is coded as a binary variable, with closed-price and open-price contracts being assigned a value of 1 and 0, respectively.

4.1.2 | Value of OEM's preexisting resources

This variable is a five-item, 7-point Likert scale that measures how much customer values the OEM's end-product commands over competing products. Specifically, consistent with our theoretical construct, this variable (*OEM product strength*), adapted from Ghosh and John (2005), measures how strong the OEM's product is in terms of price premium, customer perception, and its competitive advantage compared to products offered by its focal competitors. It hence constitutes a measure of the OEM's underlying preexisting resources and capabilities (Wernerfelt, 1984) that a supplier may potentially appropriate.[7]

[6]Two items that measure informant involvement in, and knowledge of, the procurement relationship were used to assess the quality of the key informants. The involvement question, "How involved are you personally in your business unit's dealings with the supplier?" received an average score of 6.40 ($SD = 0.66$, range = [4, 7]) and the knowledge question, "How knowledgeable are you in general about your firm's dealings with this supplier?" received an average score of 6.38 ($SD = 0.70$, range = [5, 7]) suggesting a reasonably high level of understanding of the business relationship. Finally, tests of nonresponse bias between early versus late responders showed no statistically significant differences on key demographic variables pertaining to the procurement ties, including annual volume of purchase, number of potential suppliers of the focal component, and the proportion of purchase of the component from this supplier. We conducted this test at various cut-off levels—responses within 5 weeks versus after 5 weeks, 80% early versus 20% late, and 50% early and 50% late (median) cutoffs. The results were invariant to the cut-off criteria.

[7]Some resources resulting in high product strength may be unappropriable (for instance, due to patents) while some other resources resulting in low product strength may be appropriable. However, our empirical results, which show a significant and consistent effect of product strength on contract choice, suggest that our measure captures the risk of appropriation reasonably well.

TABLE 2 Measures and descriptive statistics

Variable	Measure	Mean	*SD*	Min	Max	*N*
Supplier's specific investment (six items) $\chi^2(9) = 20.84$; CFI = 0.98; RMSEA = 0.09; reliability = 0.91	1. This supplier has made significant investment in tools and equipment dedicated to the relationship with us. 2. The procedure and routines developed by the supplier for their item(s) are tailored to our particular situation. 3. This supplier has spent significant resources designing the specifications for their item(s) to ensure that it fits well with our production capabilities. 4. We have some usual technological norms and standards which have required extensive adaptation on the part of this supplier. 5. Most of the training that the supplier's people have undertaken related to our requirement for this item(s) cannot be easily adapted for use with another customer. 6. Training personnel has involved a substantial commitment of time and money on the part of the supplier.	3.77	1.03	1	6.5	155
End-product enhancement (two items) Reliability = 0.77	1. This relationship has allowed us to better capture design and engineering synergies between the component and our end product. 2. This relationship has enhanced customer perception of our end-product's performance	4.21	1.33	1.5	7	155
Price format (closed-price contract = 1; open-price contract = 0)	How would you describe the pricing arrangement for the item(s) under this contract? Closed-price contract if fixed price or specified prices with verifiable adjustment formulas (e.g., inflation, produce price index, etc.) over the length of the contract. Open-price contract if prices are not specified ahead of shipment or specified prices with negotiated adjustments.	0.82	0.39	0	1	155
OEM product strength (five items) $\chi^2(5) = 7.54$; CFI = 0.99; RMSEA = 0.06; reliability = 0.81	1. This end product is very profitable for you. 2. Customers are willing to pay a large premium for your end product. 3. You earn higher margins on your end product than your competition. 4. Customers value your end product more than competing products. 5. You enjoy a number of competitive advantages in your end-product market.	4.47	1.20	1.6	7	155
Interface complexity	Item has a complex interface with other components in the end product.	4.68	1.32	1	7	155
Tenure[a]	How long has your business unit had a business relationship with this supplier? (year)	8.14	4.91	1	25	155
Technological uncertainty (three items)	1. Industry standards for this item's performance specifications are very unpredictable. 2. Industry standards for this item's design specifications are very unpredictable.	2.80	1.09	1	6	155

TABLE 2 (Continued)

Variable	Measure	Mean	*SD*	Min	Max	*N*
Reliability = 0.81	3. Technological developments related to this item are very unpredictable.					
Component importance	Item is a very important element of the end product.	5.12	1.22	1	7	155
Contract enforceability	The terms of our formal contract can be readily enforced in court, if necessary.	3.84	1.35	1	7	155
OEM's relative size[a]	With respect to your last year's sales volume over all products, how large is your firm relative to this supplier?	7.33	15.12	0.01	100	151
Number of potential suppliers[a]	What is the total number of potential suppliers for this item?	34.28	116.04	2	1,000	151
Supplier's irreplaceability	Suppose your firm were to switch suppliers and start purchasing the item(s) from a new supplier. How much time would the switchover take? (consider the time required to locate, qualify and train the new source, retrain your employees, make necessary investments, conduct testing, etc.): (1) less than 1 month; (2) 1–3 months; (3) 4–6 months; (4) 7–9 months; (5) 10–12 months; (6) 13–24 months; (7) over 24 months.	3.30	3.23	0.5	18.5	151
Norm of flexibility (four items) $\chi^2(2) = 2.96$; CFI = 0.99; RMSEA = 0.06; reliability = 0.91	1. Both parties are expected to be flexible in response to requests made by the other. 2. It is expected that parties will make adjustments in the ongoing relationship to cope with changing circumstances. 3. The parties are open to the idea of making changes, even after an agreement is made. 4. Changes in the terms of the contract are not ruled out, if considered necessary.	4.55	1.00	1.5	7	151
Norm of long-term orientation (four items) $\chi^2(2) = 8.97$; CFI = 0.93; RMSEA = 0.15; reliability = 0.93	1. The parties expect this relationship to last a long time. 2. It is assumed that the renewal of the relationship will generally occur. 3. The parties are expected to make plans not only for the terms of individual purchases, but also for the continuation of the relationship. 4. Parties are expected to focus on long-term goals in this relationship.	4.55	1.00	1.5	7	151
Monitoring of supplier (five items) $\chi^2(5) = 4.19$; CFI = 1.00; RMSEA = 0.00; reliability = 0.75	1. Product quality 2. Price competitiveness 3. Item(s) specifications 4. Supplier's manufacturing procedures 5. Supplier's use of quality control procedures	3.91	0.81	1.8	6.6	151
Control of decision rights (six items)	1. Delivery schedule of item(s) 2. Order quantities of item(s) 3. Pricing of item(s) (e.g., price determination, adjustments allowed, etc.)	4.05	0.70	1.8	6.6	151

TABLE 2 (Continued)

Variable	Measure	Mean	*SD*	Min	Max	*N*
$\chi^2(9) = 19.63$; CFI = 0.90; RMSEA = 0.141; reliability = 0.62	4. Ongoing design and engineering changes 5. Supplier's production processes and manufacturing technology 6. Supplier's quality control procedures					
OEM's investment (four items) Reliability = 0.89	1. You have made a significant investment in tools and equipment dedicated to the relationship with this supplier. 2. This supplier has some usual technological norms and standards which have required extensive adaptation on your part. 3. Most of the training that the supplier's people have undertaken related to your requirement for this item(s) cannot be easily adapted for use with another customer. 4. Training this supplier's people has involved a substantial commitment of time and money.	3.46	1.19	1	6.5	151

Note: The anchors for scale points are 1 = "strongly disagree" and 7 = "strongly agree." The table provides an illustrative item for all multi-item scales, except that *Control of decision rights* is rated from "Entirely decided by this supplier" to "Entirely decided by your firm" and *Monitoring of supplier* is rated from "Minimal monitoring of supplier" to "Extensive monitoring of supplier" on a 1–7 scale.

[a]We use natural log of this variable in our estimations.

4.1.3 | Importance of adaptation

This is measured by *Interface complexity*, a single-item scale that rates the complexity of the *interface* between the component and the end product. An OEM's end product has hundreds of component parts manufactured by various suppliers. The more complex the interface among these components, the more difficult it is to pre-specify all the architectural and technical interactions among them. Consequently, when random events require the OEM to modify parts of such a complex system (e.g., a component produced by another supplier), the focal supplier must also engage in unscheduled adaptation of its own component.[8] In contrast, adaptation of the focal component is less likely to be needed in a noncomplex system where modifications of one part do not require simultaneous modifications of other parts. Note that this interface of the focal component with other components is primarily a function of the architecture and design features of the OEM's end product as well as the nature of the architectural and engineering "communication" among the components. Hence, interface complexity can be viewed as an exogenous feature of the buyer–supplier relationship.

4.1.4 | Supplier's specific investment

We asked the purchasing manager of each OEM to rate on a six-item, 7-point Likert scale how extensively the supplier is required to invest in resources, efforts, and training to produce the component that fits the OEM's end product. This measure, *Supplier's specific investment*, denotes a broad spectrum of tangible and intangible investments undertaken by the supplier. Our informants suggested that their agreements do not usually describe in detail the specific investments to be made by the supplier, due to the costs of stating ex ante the component's production requirements. Likewise, these contracts almost never specify how much value the collaboration should add to the OEM's end product, although they may stipulate technical specifications of the component or subsystem being procured. These facts suggest that the supplier's specific investments are likely to be non-contractible in our context.

4.1.5 | Value add to OEM's end product

To measure the value add generated in the relationship—*End-product enhancement*—the key informant managers rated on a two-item, 7-point Likert scale the extent to which the procured component has helped to enhance the OEM's end-product performance and capture design and engineering synergies.

We include a number of control variables in our empirical analyses. First, when the OEM's *ex ante* bargaining power (i.e., its bargaining power prior to entering a relationship with a particular supplier) is high, the OEM may seek a closed-price format to commit the supplier to a fixed and probably low price. To control for this, we use the total *Number of potential suppliers*

[8]As an illustration, consider two automobile components—the engine and the spoiler (also known as the rear wing). The engine has a complex mechanical, electrical, and software interface with the rest of the car, such that changes in transmission or brake subsystems require corresponding adaptations of the engine. In contrast, changes in the transmission or brake subsystems do not require adaptations to the spoiler, which therefore has low interface complexity.

for the component and additionally construct a measure called *OEM's relative size*—which is the ratio of the OEM's to supplier's dollar sales volume, both in terms of their full portfolio of products. Likewise, the OEM's ex post bargaining power might be lower if the supplier cannot be replaced easily. As such, the OEM might be forced to renegotiate despite the presence of a closed-price format. To control for this, we use *Supplier irreplaceability*, which measures the number of months that the OEM needs to replace the current supplier with a new one. We also control for the importance of the component in the OEM's end product (*Component importance*) in our regressions.

Second, parties might stipulate closed-price formats only when they perceive that such formal contractual provisions are enforceable by courts. We measured this using a 7-point *Contract enforceability* item, which we expect to be positively correlated with the use of closed-price formats. Third, several papers adopting the TCE framework have argued that closed prices are costly to renegotiate, and thus less useful in uncertain environments where the terms of trade need to be frequently adapted (e.g., Bajari & Tadelis, 2001; Crocker & Reynolds, 1993; Lo et al., 2012). To control for this, we include *Technological uncertainty* (a three-item scale) in our regressions. In contrast to interface complexity at the component level, this measure captures factors that make technology unpredictable at the *industry* level, such as changes in the material science underlying the component (e.g., hardened plastic instead of ceramic or steel, or copper instead of aluminum wires). Unlike the last minute, idiosyncratic adaptations measured by *Interface complexity*, these industry-level changes are relatively easy to describe and incorporate into contractual amendments.

Fourth, in addition to using closed-price contracts to govern specific investment and adaptation (the key frictions in our study), OEMs may also utilize these pricing provisions to incentivize the supplier to keep production costs low. However, using such formal incentive may be less requisite if the parties expect to be in a long-term relationship and hence can rely on self-enforcing agreements and "relational governance" to sustain cooperation. To control for this possibility, we include in our estimations *Tenure*, which measures the length of the parties' relationship in number of years and has been used both as a proxy for the expected future duration of the relationship and as a proxy for the strength of relational norms and social ties (Corts & Singh, 2004; Kalnins & Mayer, 2004), and *Norm of long-term orientation*, which measures on a four-item, 7-point Likert scale the likelihood of future interactions. Cooperative norms have also been shown to be important in industrial contexts (e.g., Anderson & Weitz, 1992; Heide & John, 1990). Accordingly, we include *Norm of flexibility*, a four-item, 7-point Likert scale, to measure how flexible the parties are in making adjustments to unforeseen circumstances and requests.

Finally, firms may adopt alternative governance mechanisms in addition to price formats. Our regressions control for three of the commonly used ones: hostages, monitoring rights, and control rights. Regarding hostages, a supplier may be hesitant to commit specific investments due to the classic hold-up concern. However, if the OEM also makes a specific investment, that commitment itself would mitigate such concerns (Anderson & Weitz, 1992; Williamson, 1983). To control for this, we use a four-item, 7-point Likert scale to capture the level of *OEM's investment*. To control for OEM's monitoring activities that help to discover quality control issues in contract manufacturing, we use *Monitoring of supplier*, which measures the extent of OEM's monitoring across five upstream activities, such as manufacturing processes, quality, and technical specifications. Finally, we include the variable *Control of decision rights* that measures OEM's contractual control over its supplier on five key decisions in their relation, such as delivery schedule, engineering design, and quality control processes.

Some TCE studies (e.g., Joskow, 1987 on electric utilities; Crocker & Masten, 1991 on natural gas) point out that an additional relevant control variable in empirical analyses of closed versus open prices is contract duration. According to these studies, duration should be included as a control variable because the need to prevent haggling costs and holdup calls for long-term contract duration, which in turn calls for open price terms to retain flexibility. While our survey does not contain specific information on contract duration, it is well known that in the electric and electronics industries, contract duration is rarely longer than 1 year (e.g., Poppo, Zhou, & Ryu, 2008) as OEMs must revamp their products on a regular basis (at most every 2–3 years). Thus, controlling for duration is unlikely to be critical in our context.

4.2 | Measure reliability and validity

We employed confirmatory factor analysis (CFA) to assess the validity of our multi-item measures. The CFA model included the measures for the OEM's strength in its downstream end-product market, the norm of flexibility, and technological uncertainty. The CFA model suggested an acceptable model fit ($\chi^2 = 212.63$, $p < .05$; NNFI = 0.946; CFI = 0.952; RMSEA = 0.063). Each item loaded significantly (minimum of 0.62) on each of the hypothesized constructs, indicating good convergent validity. In addition, the average variance extracted (AVE) ranged from 0.61 to 0.77, and we found that the AVE for each construct exceeded the squared inter-construct correlations, suggesting good discriminant validity (Fornell & Larcker, 1981). Overall, our analysis indicates that our measures and constructs are reliable.

Common method variance is always a concern, especially with perceptual measures in survey data collected from one source. We used a marker variable approach suggested by Lindell and Whitney (2001) to test for common method variance. Specifically, we utilized two different variables: qualification of service provided by the supplier, and monitoring of the supplier's quality control procedures. We then estimated the correlations between all of our relevant constructs and each of these variables, and found that none of the correlations were significant ($p > .10$). In addition, we also used the Harmon one-factor test (Harmon, 1976) and found that the highest factor accounted for only 9.05% of the total variance explained. Together, these results suggest that common method variance is not a concern in our data.

5 | EMPIRICAL ANALYSIS

5.1 | Estimation approach

Based on the predictions from our theoretical model discussed above, we test our three sets of empirical hypotheses at the collaborating OEM-supplier dyad level. First, to test Proposition 3 on the choice of price format, we use a probit model in which price format used in the buyer–supplier relationship is the binary-dependent variable, and *OEM product strength*, *Interface complexity*, and their interaction term are the key explanatory variables. Since each industry may feature distinctive practices, norms, and other unobserved heterogeneity, we cluster the *SE*s by SICs in our regressions.

Proposition 3 in our theoretical model implies that a high value of the OEM's preexisting resources should lead the parties to choose an open-price contract when adaptation is unimportant and a closed price contract when adaptation is important. To find empirical support for this prediction, we should observe (a) a negative main effect of OEM's preexisting resources on the choice of a closed price but a positive interaction between such resources and adaptation needs. It is important to keep in mind that in a linear regression, the signs of the estimated coefficients would determine the directions of the main and interaction effects. However, determining those directions is more involved in nonlinear regressions such as probit (Norton, Hua Wang, and Chunrong Ai (2004)) as the main and interaction effects depend not only on the estimated coefficients but also on the selected sample points. We take this issue into account below when interpreting our probit results. Online Appendix B provides additional econometric analyses and results.

Testing Propositions 1 and 2 of the model requires us to estimate the effect of a switch from open price to closed price on supplier's specific investment and value creation. Since price format is an endogenous decision variable, simply regressing the dependent variable, *Supplier's specific investment* or *OEM's end-product enhancement*, on *Price format* would generate biased and inconsistent estimates (Heckman, 1978; Lee, 1978). To correct for the endogeneity of *Price format* and its interaction with adaptation in testing Propositions 1 and 2, we follow the procedure for estimating average treatment effects using instrumental variables proposed by Wooldridge (2010, p. 939). Specifically, we use a 2SLS regression with instrumental variables to estimate the "treatment" effect of price format in which the outcome variable is *Supplier's specific investment* or *OEM's end-product enhancement*, and *Price format*, *Interface complexity* and their interaction term are the main explanatory variables. We cluster *SE*s by SICs.

To construct the instrument for *Price format* to be used in the second stage linear regression, the procedure outlined in Wooldridge (2010) requires generating predicted values of *Price format* and of its interaction with *Interface complexity* through a first-stage probit regression. *Contract enforceability* is included in the first stage probit regression but excluded from the second stage linear regression. *Contract enforceability* positively correlates with the usage of the more complete closed price provision ($\rho = 0.23$) but it does not correlate with specific investment ($\rho = -0.06$), which is rarely specified contractually in our setting. This also matches to our theoretical setup in which the supplier's specific investment is non-contractible. Online Appendix B describes the details of this 2SLS approach.

5.2 | Estimation results

We present our results on the effect of OEM's preexisting resources and adaptation on the choice of price format in Table 3.

Column 1 includes *OEM product strength* and *Interface complexity* as the explanatory variables, and a minimal set of control variables. Column 2 adds the interaction between price *OEM product strength* and *Interface complexity* as an additional explanatory variable. Finally, Column 3 replicates Column 2 after including the full set of control variables.

Column 1 shows that OEM product strength is positively correlated with the usage of close-price contracts (0.31) whereas the direct effect of interface complexity (0.05) is not statistically significant at the 10% level. When the interaction term between product strength and interface complexity is included (Columns 2 and 3), the estimated coefficient of product strength is negative (−0.56 or −0.81, respectively) and the estimated coefficient of the interaction term with interface complexity is positive (0.18 or 0.30, respectively). Both effects are statistically significant at the 10% level or at lower levels. Recall, however, that unlike in a linear regression, we cannot directly interpret these coefficients in a probit model as the main and interaction effects.

TABLE 3 The effect of preexisting resources and adaptation on price format

Dependent variable	***Price format closed-price contract* = 1; *open-price contract* = 0 (probit)**		
	(1)	**(2)**	**(3)**
Main variables			
OEM product strength	0.31 (0.18)	−0.56 (0.13)	−0.81 (0.50)
Interface complexity	0.05 (0.22)	−0.68 (0.24)	−1.18 (0.49)
OEM product strength × *Interface complexity*		0.18 (0.01)	0.30 (0.11)
Control variables			
log(*tenure*)	0.02 (0.15)	0.01 (0.18)	−0.04 (0.30)
log(*OEM's relative size*)	−0.02 (0.03)	−0.01 (0.02)	−0.01 (0.03)
Component importance	−0.16 (0.03)	−0.18 (0.04)	−0.12 (0.08)
Contract enforceability	0.26 (0.07)	0.30 (0.07)	0.30 (0.06)
Technological uncertainty			−0.37 (0.15)
Log (*No. potential suppliers*)			0.19 (0.15)
Supplier irreplaceability			−0.22 (0.31)
Norm of flexibility			−0.16 (0.19)
Norm of long-term orientation			0.14 (0.16)
Control of decision rights			−0.35 (0.19)
Monitoring of supplier			−0.07 (0.06)
OEM's investment			−0.01 (0.14)
SIC35	−0.05 (0.03)	−0.09 (0.04)	−0.09 (0.09)
SIC36	0.36 (0.05)	0.34 (0.02)	0.13 (0.15)
Constant	−0.88 (0.54)	2.65 (0.67)	6.51 (3.11)
Adjusted R^2	.146	.173	.347
N	155	155	151

Note: SIC-clustered *SE*s in parentheses.

As discussed above, these effects also depend on other estimated coefficients and values of the independent variables.

Using the estimates in Column 2 of Table 3, setting the value of interface complexity at zero, and assuming all independent variables, including OEM's product strength, take their mean values, the estimated main effect of product strength on the probability to choose the closed price format has a mean of −0.20 (with $SE = 0.14$, p-value = .16). This negative effect is consistent with Proposition 3 in our theoretical model. Figure B1 and its corresponding table in our online Appendix B show the main effects of OEM product strength on the probability to choose closed price as consistently negative across the value range of OEM product strength. The results remain robust if we use of estimates in Column 3 of Table 3 instead of the estimates in Column 2. In that case, the main effect of product strength has a negative mean of −0.28 ($SE = 0.28$, p-value = .32).

Similar to the main effect, the effect of the interaction between product strength and interface complexity on contract choice cannot be directly inferred from the estimated coefficient of the interaction term. To recover this interaction effect, we follow the procedure proposed by Norton et al. (2004). The typical interaction effect in our samples is positive (mean = 0.03), tightly distributed (*SD* = 0.027), and statistically significant (the mean z-statistic = 2.81, $p < .01$). In line with other studies that analyze regressions with binary-dependent variables (e.g., Huang & Shields, 2000), we interpret the fact that our estimated main effect is negative and our estimated interaction effect is predominantly positive as consistent with Proposition 3 from our theoretical model. Figure B2 in the online Appendix B and the associated summary statistics show the results in detail.

TABLE 4 The effect of price format and adaptation on specific investment

Dependent variable	***Specific investment* (2SLS)**		
	(1)	**(2)**	**(3)**
Main variables			
Price format	−0.51 (0.57)	4.03 (0.66)	1.32 (0.22)
Interface complexity	0.12 (0.02)	0.90 (0.09)	0.35 (0.05)
Price format × *Interface complexity*		−0.94 (0.08)	−0.34 (0.07)
Control variables			
OEM product strength	0.18 (0.01)	0.21 (0.01)	0.28 (0.08)
log(*tenure*)	0.14 (0.04)	0.10 (0.02)	−0.00 (0.09)
log(*OEM's relative size*)	0.06 (0.05)	0.07 (0.06)	0.10 (0.04)
Component importance	0.09 (0.04)	0.14 (0.03)	0.02 (0.05)
Technological uncertainty			−0.05 (0.06)
Log (*No. potential suppliers*)			−0.11 (0.08)
Supplier irreplaceability			0.14 (0.04)
Norm of flexibility			0.22 (0.04)
Norm of long-term orientation			0.04 (0.01)
Control of decision rights			−0.28 (0.09)
Monitoring of supplier			−0.18 (0.09)
OEM's investment			0.25 (0.06)
SIC35	0.07 (0.03)	−0.09 (0.03)	0.07 (0.05)
SIC36	0.29 (0.04)	0.07 (0.05)	0.16 (0.01)
Constant	1.93 (0.77)	−1.95 (0.75)	0.73 (1.28)
Partial F statistics of IVs			
Price format	49.17	22.34	805.24
Price format × *Interface complexity*		12.47	346.32
R^2	.149	.055	.386
χ^2	5.40	102.46	37.24
N	155	155	151

Note: As prescribed in Wooldridge (2010, p. 939), the 2SLS models follow the two-step procedure that estimates average treatment effects using IVs. The first-step probit model that generates $\widehat{G}_i$ uses *Contract enforceability* as the excluded instrument and the control variables in the corresponding column as included instruments. See details on the procedure and instruments under Section 5. SIC-clustered *SE*s in parentheses.

The results on the control variables in Table 3 are qualitatively similar across the three models. We find component importance to be negatively correlated with the use of closed price formats (although the estimate in Column 3 is not statistically significant at the 10% level). As expected, contract enforceability has a significant and positive effect on the use of closed price; at the same time, tenure and OEM-supplier relative size have no relationship

TABLE 5 The effect of price format and adaptation on value add

Dependent variable	***Value add* (2SLS)**		
	(1)	**(2)**	**(3)**
Main variables			
Price format	−1.17 (0.72)	2.91 (2.28)	2.63 (1.10)
Interface complexity	0.09 (0.01)	0.11 (0.03)	−0.00 (0.14)
Price format × *Interface complexity*		−0.84 (0.44)	−0.41 (0.15)
Control variables			
OEM product strength	−0.00 (0.02)	0.70 (0.37)	0.25 (0.12)
log(*tenure*)	−0.04 (0.08)	−0.08 (0.10)	−0.07 (0.12)
log(*OEM's relative size*)	0.01 (0.06)	0.02 (0.06)	0.07 (0.02)
Component importance	0.09 (0.05)	0.13 (0.02)	−0.07 (0.01)
Technological uncertainty			0.17 (0.08)
Log (*No. potential suppliers*)			−0.20 (0.03)
Supplier irreplaceability			0.26 (0.08)
Norm of flexibility			0.38 (0.09)
Norm of long-term orientation			0.09 (0.03)
Control of decision rights			0.12 (0.08)
Monitoring of supplier			0.11 (0.07)
OEM's investment			0.24 (0.02)
SIC35	0.06 (0.04)	−0.08 (0.11)	0.11 (0.05)
SIC36	−0.12 (0.07)	−0.31 (0.13)	−0.25 (0.09)
Constant	4.43 (0.83)	0.94 (1.64)	−1.42 (1.19)
Partial F statistics of IVs			
Price format	49.17	22.34	805.24
Price format × *Interface complexity*		12.47	346.32
R^2	.017		.361
χ^2	2.91	6.78	5.86
N	155	155	151

Note: As prescribed in Wooldridge (2010, p. 939), the 2SLS models follow the two-step procedure that estimates average treatment effects using IVs. The first-step probit model that generates $\widehat{G}_i$ uses *Contract enforceability* as the excluded instrument and the control variables in the corresponding column as included instruments. See details on the procedure and instruments under Section 5. SIC-clustered *SE*s in parentheses. R^2 in two-stage-least-square approach could be negative because the second stage regression is minimizing residuals with the predicted values of endogenous variables whereas R^2 is calculated with another set of residuals obtained with original values of those endogenous variables. Detailed explanations can be found in https://www.stata.com/support/faqs/statistics/two-stage-least-squares/, accessed on May 27, 2021.

with price format. In Column 3, the negative effect of technological uncertainty implies that more unpredictable industry-wide technical standards are associated with open prices. We also find that OEMs are less likely to use closed price formats when they control decision rights.

As attest of Proposition 1 in the model, Table 4 below presents the results of 2SLS regressions that show how contracts directly affect specific investment. Column 1 includes *Price format* and *Interface complexity* as explanatory variables, and the minimal set of controls. Column 2 includes the interaction between *Price format* and *Interface complexity* as an additional explanatory variables. Finally, Column 3 expands Column 2 by including the full set of controls.

Column 1 shows that a closed price has a negative but statistically insignificant effect on investment (−0.51). After we include the interaction term in Columns 2 and 3, however, the main effect of closed price on investment turns positive (4.03 and 1.32, respectively) whereas the interaction effect becomes negative (−0.94 and −0.34, respectively), both coefficients being statistically significant at the 1% level. These results imply that a closed price increases the supplier's specific investment, relative to the open price, when adaptation is unimportant (low *Interface complexity*), and decreases it when adaptation is important (high *Interface complexity*). These results are consistent with our integrated TCE model in which the choice of specific investment jointly affects haggling and adaptation frictions (Proposition 1), and is entirely novel to the literature. Figure B3 in online Appendix B further illustrates these results, using the coefficients from Column 2 of Table 4.

Regarding the control variables, OEM product strength, tenure, and component importance have strong positive effects on specific investment, although coefficients of the latter two variables become insignificant at the 10% level once the full set of controls is included in Column 3. Column 3 shows that both the difficulty of replacing the focal supplier and the supplier's control rights positively correlate with supplier's specific investment, possibly because both variables capture safeguards against holdup by the OEM. The norm of flexibility and long-term orientation, as well as collaborating through OEM's own specific investment, motivate specific investment. However, increased monitoring by the OEM decreases the supplier's investment, possibly because it indicates low trust within the relationship. At the bottom of Table 4, we report the partial F-statistics for the first-stage regressions. These range from 12.47 to 805.24, much larger than Staiger and Stock's (1997) suggested value of 10, confirming that our instruments are robust.

Finally, and in line with our theoretical Proposition 2, Table 5 and Figure B4 in the online Appendix B provide evidence on how price formats affect the value the supplier creates for the OEM, as measured by *OEM end-product enhancement*. The results are qualitatively similar to those on supplier's specific investment in Table 4, and entirely consistent with Proposition 2 in our model: closed price increases value creation when adaptation is relatively unimportant (low *Interface complexity*) and decreases it when adaptation is important (high *Interface complexity*). This is not surprising because specific investments generally increase value creation within a relationship, and the two are indeed positively correlated ($\rho = 0.36$) in our sample.

6 | DISCUSSION

We have developed a formal model that integrates three key contracting frictions in OEM-supplier relationships—namely, haggling as a result of the hold-up problem, insufficient adaptation to unforeseen contingencies, and the risk of appropriation of preexisting resources. We have shown theoretically how contract forms determine the supplier's specific investment under different combinations of these frictions, and tested the predictions from our integrative model using proprietary data on procurement contracts obtained on 155 OEM-supplier ties.

Our work uncovers two features of contractual governance that have remained unexplored in standard TCE analyses. First, which contract forms increase or decrease the supplier's incentive to undertake specific investments is a priori ambiguous, and depends on the relative importance of haggling and adaptation frictions. Second, when specific investments facilitate appropriation of the buyer's preexisting resources, the conventional governance role of contracts is potentially reversed—that is, contracts may not be used to enhance but rather to *dis-incentivize* specific investment. Since the value of preexisting resources and capabilities is a feature of the buyer (rather than of its transaction or relationship with the supplier), this second result implies that different buyers with differential preexisting resources will seek different governance forms (investment-incentivizing or investment-disincentivizing) for their relationship with *the same* supplier. By incorporating such "strategic" buyer-specific appropriation concerns into the transaction-specific TCE framework, our paper therefore offers a formal basis for what scholars call is "a strategic theory of the firm" (Foss & Foss, 2005; Ghosh & John, 2005; Madhok, 2002).

From a managerial standpoint, our evidence suggests that in designing their contracts with suppliers, OEMs balance the *relative* importance of ex post value capture (through the adaptation of components), the potential for holdup and haggling, and the risk of appropriation of their unique resources, all of which are enhanced by the supplier's specific investment. Managers working at OEMs that bring proprietary technologies, product design skills, and customer bases, into their contractual relationships with suppliers, and who have so far not paid attention to the interaction between adaptation benefits and haggling and appropriation costs of suppliers' specific investments, may therefore benefit from reading our research and learning what other professionals in their industry do.

We conclude by discussing some limitations of our study and implications for future work. First, we use contract-level data obtained via a survey instrument. Even though necessary precautions were undertaken during the collection of the data, and even though our measure validation results suggest that common method bias is not significant in our data, these issues cannot be completely ruled out. It would hence be useful for future studies to use direct, transactional data to study similar effects. Second, to directly test the hypothesis that specific investment leads to the appropriation of preexisting resources, which is consistent with our data, future studies may combine information on value creation within a relationship and longer-term appropriations external to the relationship (e.g., Alcacer & Oxley, 2014). Third, our analysis focuses on the indirect role of price terms—via dis-incentivizing investment—in safeguarding the OEM buyers' preexisting resources. Depending on the institutional context, companies could also use other, more direct instruments, such as exclusive contracts, non-compete clauses, and intellectual property laws, to serve this purpose. It would be fruitful to investigate the roles of these instruments, both separately from and interactively with the price formats. Finally, in many contexts such as automobile and jet manufacturing and information technology services, both OEMs and suppliers may make specific investments and bring preexisting resources and capabilities into their relationship. Future studies focusing on more complex alliances may exploit our framework to shed light on how firms design and manage their governance arrangements in such "two-sided" scenarios.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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