"STRATEGIZING CALCULUS" IN INDUSTRIAL PROCUREMENT CONTRACTS: SAFEGUARDING PRE-EXISTING RESOURCES VERSUS CREATING VALUE

Desmond (Ho-Fu) Lo
Assistant Professor of Marketing
Leavey School of Business
Santa Clara University
500 El Camino Road, 221K Lucas Hall
Santa Clara, CA 95053
Phone: 408-554-4716
Email: hlo@scu.edu

Giorgio Zanarone
Associate Professor of Business Organization
Colegio Universitario de Estudios Financieros
Leonardo Prieto Castro 2
28040 Madrid, Spain
Phone: (34) 914-480-892
Email: gzanarone@cunef.edu

and

Mrinal Ghosh
Professor of Marketing
Eller College of Management
University of Arizona
1130 E Helen Street, 320P McClelland Hall
Tucson, AZ 85721
Phone: 520-626-7353
Email: mghosh@email.arizona.edu

This study received financial support from the Spanish Ministry of Economy and Competitiveness through grant ECO2014-57131-R. We thank Robert Gibbons, Kristina McElheran, Alfonso Miranda, Joanne Oxley, Birger Wernerfelt, Michael Whinston, and participants at the ISNIE and ISBM conferences for helpful comments. The usual caveat applies.

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Abstract

Extant research in collaborative ties has pre-dominantly focused on studying how governance forms balance the potential gains against transaction hazards within that relationship. Building on the incomplete contracting approach, we develop a game-theoretical model that shows how buyers trade-off gains *within* a supplier relationship against protecting their own resources that exist *outside* the relationship. We show that compared to open-price contracts, closed-price contracts that dis-incentivize suppliers from over-investing in activities that facilitate appropriation, provide better protection to such pre-existing resources. Consistent with our model, but not with alternative theories, our data on procurement contracts show that OEMs tend to use closed-price contracts when their pre-existing resources are high but the use of closed-price contracts reduces *both* the supplier’s dedicated investments *and* the OEM’s gains. Our work provides evidence on how parties, cognizant of the dark side of relationships, strategically trade-off protecting pre-existing resources against generating value within inter-organizational relationships.

Keywords: Contract, Governance, Firm resources and capabilities, Transaction Cost Economics, Resource-Based View, Pricing.

JEL codes: D23; L14; L22; M21; M31

1. Introduction

In business-to-business, supply chain, and distribution channel settings, firms often enter into strategic alliances or collaborative ties to offer products or services that are sources of competitive advantage (e.g., Mowry, Oxley, and Silverman 1996; Jap 1999). These value-added products or services are created through investments in partner-specific assets, processes, and routines as well as through information and knowledge sharing (e.g., Powell, Koput, and Smith-Doerr 1996; Khanna, Gulati, and Nohria 1998; Lee 2011) that may leverage an individual firm's pre-existing resources like technological, engineering, and product development skills, brand equity, and channel capabilities (e.g., Moorman and Slotegraff 1999; Dussauge, Garrett, and Mitchell 2000; Lo, Frias, and Ghosh 2012). A vast body of literature, both theoretical (Williamson 1979; Grossman and Hart 1986; Zanarone, Lo, and Madsen 2015) and empirical (e.g., Heide 1994; Reuer and Arino 2007; Schepker et al. 2014) has focused on contract design approaches to encourage parties to make efficient, value-enhancing investments.

Frequently, however, such potentially value-enhancing investments and activities undertaken by one's partner, say a component supplier, could be hazardous to the other party, say the original equipment manufacturer (OEM), in the sense that it exposes the OEM's pre-existing, *non*-relationship-specific resources to opportunistic appropriation. Once such sensitive and firm-specific strategic information is learned during the investment process, the partner could harm, or threaten to harm, the value the OEM derives from its pre-existing resources (Hamel, Doz, and Prahalad 1989; Mohr and Sengupta 2002; Arora and Merges 2004; Arruñada and Vázquez 2006). Such appropriation could take many forms. For instance, the supplier may use his acquired knowledge and built-up capabilities to shade on quality (Anderson and Jap 2005) or exploit the spillover from innovations (e.g., Reich and Mankin 1986; Powell, Koput, and Smith-Doerr 1996; Dutta and Weiss 1997) and sell competing products as is evidenced from the experience of many European and Japanese luxury automobile manufacturers in the Chinese markets (e.g., the Audi A4 versus the YEMA F-16), as well as in the computer hardware (Arruñada and Vázquez 2006) and the cellular phone (Alcacer and Oxley 2014) industry. Likewise, one recent litigation between

Apple Inc. and Samsung is specifically centered on Samsung introducing smart phones based on Apple's technology that Samsung potentially secured while designing and supplying memory-chips to Apple (The Economist 2012). Such concerns regarding opportunistic appropriation of one's proprietary knowledge resources are also prevalent in inter-governmental defense contracts[1] and manufacturer-retailer relationships[2]. These instances are not exceptions; rather, scholars have associated such deliberate "dark-side" motivations with suppliers being "aggressive" in learning and building their capabilities during collaborations (e.g., Hamel et al. 1989; Jap and Anderson 2003; Arruñada and Vázquez 2006).

The critical aspect to note again is that these firm-specific resources are extra-relational and not created within the inter-firm collaborative tie; however, the economic rents derived from these firm-specific, extra-relational resources may be exposed to hazards arising within the collaborative tie (Helper and Levine 1992; Klein 1996). As such, collaborative ties that have the potential of creating value act as a "double-edged sword" for the firm possessing these extra-relational resources. This observation leads us to ask the following key question: *What are the contract design implications of such vulnerable, extra-relational resources in inter-firm ties*? In this paper, we address this central issue by presenting a formal model of procurement contracts that investigates the trade-off between value-creation and resource protection and by taking the model to micro-level contractual data on OEM-component suppliers agreements.

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[1] For instance, one of the purportedly major stumbling blocks between Russia and China on the sale of the latest 4++ generation, Russian made, Sukhoi SU-35 advanced fighter jet has been the number of units of SU-35 that would be produced under a joint licensing and production arrangement (for which Russia would get paid). Russia has been pushing for a supply of 48 units under a "strict" licensing contract whereas China originally wanted only 4 such units and a technology transfer agreement. The Russian anxiety is justified because in the past China has unilaterally cut the number of units that would be produced under such joint production agreements (e.g., the Shenyang J-11 which is based on the Sukhoi SU-27). As it current stands, the current versions of the J-11 is a direct competitor of the SU-27 in the international market for 4th generation fighter aircrafts.

[2] Consider the iconic relationship berween Walmart and Proctor & Gamble (P&G) where both parties have made investments in efficient consumer response practices per which inventory management and replenishment of supplies to individual stores are calibrated to the specific turnover rate of SKUs at that store. Making optimal timing and quantity replenishment decisions would require Walmart to provide P&G with access to retail data on turnover rates, quantities sold, pricing, and promotional patterns; however, Walmart has always been very adamant on *not* sharing this data because it has feared P&G might use this knowledge on micro-level market dynamics to (a) negotiate more favorable terms with Walmart in subsequent periods, and (b) reach more favorable sourcing arrangements with other retailers who directly compete against Walmart.

Our formal model adapts the incomplete contracting approach (e.g., Grossman and Hart 1986; Hart and Moore 1988; Zanarone, Lo, and Madsen 2015) to examine how an OEM's choice of contract form influences the supplier's within-relationship investments. We look at two contract forms. The first is a "closed-price contract" where the OEM and the supplier agree on a price ex ante. The alternative is an "open-price contract" where the price is not specified ex ante but agreed upon ex post, after the supplier makes his investment decision. The novel wrinkle we add to this standard setup is that the non-contractibility of the OEM's own pre-existing resources gets such resources entwined in this sourcing contract and makes them potentially appropriable by the supplier (Klein 1996). The OEM's optimal choice of contract form then has to induce supplier's investments that balance the value-enhancing aspects with potentially opportunistic appropriation by the supplier.

Our results show that the two firms are more likely to use a closed-price contract over an open-price contract when the OEM has high levels of pre-existing resources that are vulnerable to appropriation. A closed-price contract pre-determines the division of joint surplus, with the OEM being the residual claimant of the realized surplus. In contrast, under an open-price contract, both parties share the joint surplus by negotiating over its division ex post. Hence, compared to an open-price contract, a closed-price contract *dis*-incentivizes the supplier's investments that could be used ex post to appropriate the OEM's pre-existing resources. Therefore, closed-price contracts become more desirable to the OEM the more vulnerable its pre-existing endowments. Simultaneously, however, by *dis-incentivizing* the supplier's investments, closed-price contracts reduce customization efforts and thus the total surplus ex post.

We test the two key predictions from this formal model using proprietary, micro-contract level data obtained on 155 procurement contracts for engineering components used in industrial products. Our data provide broad support to our predictions. In particular, we find that OEM-supplier contracts are more likely to be closed-price contracts when the OEM's pre-existing resources – measured in two different ways, viz. its end-customer market strength and market share – are high. Second, using an instrumental-variable technique (two-step endogenous switching regressions: Maddala 1983 and Wooldridge 2010), we find that both the component supplier's dedicated investments and the OEM's end-product sales increase are significantly lower under closed-price contracts than under open-price ones. These results are consistent with the idea that closed-price contracts dis-incentivize the supplier's dedicated investment, thus protecting the OEMs' vulnerable resources from potential appropriation by the supplier, at the cost of reducing the total value created within the relationship. Importantly, these findings cannot be explained by alternative, conventional theories on governance design such as the property rights theory (Grossman and Hart 1986), multi-tasking models (Holmstrom and Milgrom 1991), and the classic hold up model of the Transaction Cost Economics ("TCE"; Williamson 1979).

Our research makes two main contributions. First, we contribute to the growing literature on the "dark side" of relationships (e.g., Jap and Anderson 2003; Arruñada and Vázquez 2006; Wang, Kayande, and Jap 2010) by providing evidence on (a) how incomplete contracts that increase the potential for opportunistic appropriation can be hazardous to firms possessing high levels of extra-relational resources and (b) how such firms, desiring to protect these resources, seek contract forms that minimize appropriation hazards but simultaneously sacrifice the gains from value creation. The results further provide support to Ghosh and John (1999)'s concept of "strategizing calculus" in collaborative ties, where firms design governance forms that willingly trade off within-relationship efficiency gains to safeguard extra-relational strategic assets. In essence, our findings show a novel weakness of strong firms – namely those with larger resources that are independent of the inter-firm tie – in that their strength may limit their flexibility and force them to sacrifice potentially efficient contractual arrangements.

Second, by incorporating firm-specific, pre-existing resources that are emphasized in the Resource-Based View literature, into the incomplete contracting framework, we show how firm-specific resources matter to the design of industrial procurement contracts and affect collaborative performance (Argyres and Zenger 2012). By doing so, we extend the scope of models that are applicable to governance and contract design in inter-firm collaborations (David and Han 2004). Moreover, our analyses move the study of collaborative ties from the generic theory of *the* firm to a specific theory of *a* firm (Williamson 1999; Madhok 2002).

2. Relation to Research on Governance

Our study makes contributions to two strands of research. We provide concise reviews of these streams and situate our research with respect to these literatures.

The first stream of research we contribute to is the Resource-Based View of the firm which elaborates on how firm-specific resources and capabilities, in the form of (a) proprietary technological know-how, (b) product architecture and design and development skills, or, (c) downstream marketing capabilities that create unique brand positioning, create value in the marketplace and are sources of competitive advantage (e.g., Khanna, Gulati, and Nohria 1998; Dussauge, Garrett, and Mitchell 2000; Barney 2011). Such firms often enter into collaborative ties with other firms (e.g., component and sub-system suppliers) to generate additional value through productive, idiosyncratic investments (e.g., Madhok and Tallman 1998). The predominant focus of this line of research, however, has been on how optimal governance arrangements incentivize value-generating activities *within* the relationship (e.g., Anderson and Weitz 1992; Dutta and Weiss 1997; Oxley 1997; Bensaou and Anderson 1999). However, there has been increasing realization that even *extra-relational* assets and firm-specific endowments like brand strength are at risk in such collaborative ties due to partner opportunism (e.g., Reich and Mankin 1986; Dutta and Weiss 1997; Arruñada and Vázquez 2006; Lo et al. 2012; Alcacer and Oxley 2014).

Helper and Levine (1992), Argyres (1996), and Ghosh and John (1999) were the first set of theoretical models that suggested how pre-existing, extra-relational resources that are independent of a focal collaborative relationship could be "held up" in such exchanges and how firms might design governance forms to trade-off safeguarding pre-existing assets against value-generation. Extant empirical work (e.g., Ghosh and John 2005; Lo et al. 2012) has shed light on certain aspects of these models. For instance, Lo et al. (2012) show that high level of pre-existing resources in contracts for branded components are associated with more fixed price contracts. However, these empirical studies do not analytically examine the three inter-connected factors, namely, pre-existing resources, contractual or governance arrangements, and within-relationship value creation, in a coherent manner.

The second stream of research we make contributions to is the literature on property right theory and incomplete contracting models in the tradition of Grossman and Hart (1986) and Hart and Moore (1988). The focus in these seminal works is on how to enhance the incentives of contracting parties to make productive, value-enhancing investments within the focal dyad. Thus, a key prediction from this literature is that contracting parties choose investment-enhancing contract forms while rejecting contract forms that suppress the incentives to invest (e.g., Che and Hausch 1999). Appropriation hazards arising from the presence of firm-specific, pre-existing endowments, and the consequent potential need to dis-incentivize investment, have not been a concern in this literature.

3. Model and Hypotheses

Consider an OEM (M) who seeks to procure a component from a supplier (S). This component is integrated into M's system or end-product and sold downstream to customers. Following standard convention in models of incomplete contracts (e.g., Grossman and Hart 1986; Hart and Moore 1988), we assume that both M and S are risk-neutral. In addition, to focus on the role of the OEM's pre-existing resources and capabilities on contract design, we abstract from uncertainty by assuming that the environment is deterministic – i.e., there are no market fluctuations or technological shocks.[3]

The supplier S undertakes an investment a that enables S to understand M's technology and the needs of its customers as well as build capabilities to improve the fit of its component with M's end product. Let this dedicated investment generate a value $q(a)$ for M, where $q_a > 0$. We assume that $q(\cdot)$ is concave ($q_{aa} < 0$) and $q(0) = 0$. Simultaneously, this dedicated investment by S enhances the prospect that S could use this acquired knowledge on M's technology and downstream customer needs in ways undesirable to M. As suggested in the Apple-Samsung litigation, S could, for instance, introduce an end-product that competes with M's end-product in the marketplace. Or, S could use its understanding of M's unique technologies and develop equivalent components for M's competitors. Previous research has

[3] Nevertheless, to isolate the effects of our focal interests, we do control for environmental uncertainties in our empirical analysis. See Sections 4 and 5.

provided systematic illustrations of these forms of appropriation behavior (e.g., Hamel et al. 1989; Arora and Merges, 2004; Mohr and Sengupta 2002; Arruñada and Vázquez 2006; Alcacer and Oxley 2014).

We denote S's private benefit from acting opportunistically as $\pi(a)$, and M's loss from S's opportunistic action as $\beta(a)\omega$, where ω is the value of M's pre-existing resources and capabilities. In general, ω can be interpreted as the value of M's technological, product-design, and marketing and branding capabilities that exist at the time M seeks the component sourcing contract with S. Crucially, these *pre-existing* resources, or M's endowments, are not relationship-specific because unless S appropriates them, or enriches them through its dedicated investment a, they create a value of ω irrespective of whether M buys from S or from an alternative supplier. It is very plausible that the higher the value of ω, i.e., M's pre-existing resources and capabilities, the larger the loss it could suffer due to S's potential opportunism; thus we assume a multiplicative term $\beta(a)\omega$ for the potential harm that S could inflict on M. We further assume that $\pi_a > 0$ and $\beta_a > 0$, $\pi(\cdot)$ and $\beta(\cdot)$ are concave ($\pi_{aa} < 0$, $\beta_{aa} < 0$), $\pi_{aa} - \beta_{aa}\omega < 0$, $\pi(0) = \beta(0) = 0$, and that $q_a(0)$ is large enough for S to choose a positive investment level in all scenarios analyzed in the paper.[4]

Timing. Figure 1 shows the timeline of events in our model. At stage 1, M and S choose the price terms that will govern their relationship. In particular, they choose the price format for the component being procured and agree on whether the price should be specified upfront (i.e., a fixed-price contract) or agreed upon ex post (i.e., an open-price contract). Research has shown the prevalence of such pricing practices in business-to-business settings (e.g., Crocker and Reynolds 1993; Ghosh and John 2005; Bajari, McMillan, and Tadelis 2008). At stage 2, S chooses its level of investment that is dedicated to

[4] For simplicity, we assume the value of pre-exisiting resources ω only interacts with M's loss $\beta(\cdot)$ but not with S's own benefit $\pi(\cdot)$ and value creation $q(\cdot)$. If we relaxed this assumption and allowed for ω to also interact with $\pi(\cdot)$ and $q(\cdot)$, we would obtain qualitatively identical results provided that the supplier's potential to harm the buyer through opportunistic behavior is broad relative to the potential benefit to the relationship. This condition matches the anedoctal evidence mentioned in, for instance, Hamel et al. (1989) and Arrunada and Vazquez (2006). Further, for the sake of parsimony, we use a single-period game in our model. Nonetheless, our results would immediately extend to a model in which many suppliers interact with many OEM manufacturers over an infinite sequence of periods, with each supplier being matched to one (potentially different) supplier in each period. The details can be obtained from us upon request.

M, a. At stage 3, the contract terms are executed, unless they are renegotiated. Moreover, having already made an investment a that provides it knowledge about M's technology and customer needs, S may choose to use this knowledge opportunistically, which in turn exposes M's pre-existing resources ω to appropriation. Finally, at stage 4, the payoffs are realized for M and S.

< INSERT FIGURE 1 ABOUT HERE >

Informational assumptions. We assume that S's ex ante dedicated investment a, M's pre-existing resource endowments and capabilities ω, and the investment's outcomes $q(a)$, $\pi(a)$, and $\beta(a)\omega$, are all *observable* to M and S but *non-verifiable*. Hence, in the tradition of incomplete contracts models (e.g., Hart and Moore 1988; Aghion and Tirole 1997), no contracts contingent on these variables can be enforced by third parties such as courts. We also assume that S's ex post decision to potentially act in an opportunistic manner cannot be prevented via explicit contractual clauses. For instance, while non-compete covenants and trade secret provisions may somewhat reduce S's ability to use its acquired knowledge and capability to compete with M in the short run, they often have limited duration and enforceability (e.g., Liebeskind 1996, 1997; Pooley, 1997; Arora and Merges 2004; Garmaise 2009). In essence, then, S has an opportunity at some point of time to extract private benefits from his knowledge at M's expense. Finally, following standard practice in holdup models (e.g., Hart and Moore 1988), we assume that whether or not M and S trade the component, and the price at which trade occurs, is verifiable.

3.1 First best

We begin by analyzing the benchmark first-best case where, at stage 2, rather than only look after its own interest, S unselfishly chooses its investment to maximize the joint surplus given by

$JS(a) \equiv q(a) + \pi(a) + [1 - \beta(a)]\omega - a.$

The first best is given by

$$a^{FB} \equiv argmax_a\{JS(a)\} > 0. \quad (1)$$

3.2. Open-price contract

If M and S have agreed to trade but not specified the terms of the trade (i.e. the final price) at stage 1, they will have to negotiate the price at stage 3, after S's investment is sunk. We refer to this as the "open-price contract" scenario.

As is standard practice in models of incomplete contracts, we use the Nash bargaining solution to describe the negotiation outcome: each party receives its disagreement payoff (i.e., its payoff when M and S do not trade the component) plus one half of the surplus from trade (i.e., of the difference between the joint surplus when M and S trade the component and the surplus when they do not trade it).[5] Notice that, since S's appropriation and the value of M's pre-existing resources are non-contractible, once S acquires knowledge through the investment a, it appropriates M's resources and receives private benefit $\pi(\cdot)$ regardless of whether trade occurs or not. Hence, M's and S's disagreement payoffs are $[1-\beta(a)]\omega$ and $\pi(a)$, respectively, and the surplus from trade is

$$\{\pi(a)+[1-\beta(a)]\omega+q(a)\}-\{\pi(a)+[1-\beta(a)]\omega\}=q(a).$$

As a result, M's and S's post-negotiation payoffs are, respectively:

$$U_M^O(a) \equiv [1-\beta(a)]\omega+\frac{1}{2}q(a), \text{ and} \quad (2)$$

$$U_S^O(a) \equiv \pi(a)+\frac{1}{2}q(a). \quad (3)$$

Given its post-negotiation payoff in (3), S's ex ante investment, chosen at stage 2, is:

$$a^O \equiv argmax_a\{U_S^O(a)-a\}>0. \quad (4)$$

Lemma: Relative to the first-best level, under an open-price contract, S's investment is inefficiently low ($a^O < a^{FB}$) at low levels of ω and inefficiently high ($a^O > a^{FB}$) at high levels of ω.

Proof: In appendix.

[5] Asymmetric bargaining power and hence unequal sharing parameters will generate identical qualitative results in comparative statics in terms of the effect of pre-existing resources on contract forms, and the effect of contract forms on investments and outcomes. Technical arguments are available upon request. In our empirical analysis, we do control for ex ante and ex post bargaining power by relative OEM-supplier size and supplier irreplaceability respectively.

As in standard holdup models (e.g., Hart and Moore 1988), when the price is open for negotiation, S appropriates only half of the value that its component adds to M's end product. However, unlike in those models, S's incentive to underinvest may be compensated by the fact that, under an open-price contract, S can use its investment to appropriate M's pre-existing resource ex post. When M's pre-existing resource ω, and hence the potential ex post loss from S's appropriation, is large, an open price contract will lead S to invest too much, relative to the first best ($a^O > a^{FB}$).

3.3. Closed-price contract

Suppose that, at stage 1, M and S agree on a closed-price contract that specifies ex ante a price p at which the parties will trade the component. At stage 3, given S's investment a, selling the component to M is efficient, so M and S will trade at the pre-agreed price, provided that doing so makes them both better off – i.e., $0 \leq p \leq q(a)$. Let $U_S^C(a) \equiv \pi(a) + p$ be S's payoff after it has sunk the investment a. Then, S's ex ante investment is given by

$$a^C \equiv argmax_a\{\pi(a) + p - a\} > 0. \quad (5)$$

Anticipating this outcome, M and S will agree at stage 1 on a price p consistent with their participation constraints – i.e., such that given p, M prefers buying from S,

$$q(a^C) + [1 - \beta(a^C)]\omega - p > 0,$$

and S prefers selling to M,

$$\pi(a^C) + p - a^C > 0.$$

Proposition 1: A closed-price contract induces the supplier to invest less than under an open-price contract ($a^O > a^C$).

Proof: In appendix.

Since S's dedicated investment increases M's value from incorporating the component into the latter's end product, using the same approach in the proof of Proposition 1, we have the following companion prediction:

Proposition 2: M's value added from incorporating S's component into the end product is larger under an open-price contract than that under a closed-price contract ($q(a^O) > q(a^C)$).

Proof: In appendix.

The intuition is as follows. A closed-price contract reduces S's incentives to invest, because the payoff that S – as a residual claimant – obtains from selling the component to M is pre-determined and hence does not depend on the investment level. Hence, when choosing its investment under a closed-price contract, S does not care about the value creation to M, $q(a)$. In contrast, S appropriates half of $q(a)$ through bargaining under an open price, which gives it an incentive to invest more.

Notice that switching from a closed-price to an open-price contract does not change S's propensity to be opportunistic: for any given investment level a, S receives $\pi(a)$ from appropriating B's resources regardless of whether the parties agree ex ante to a closed-price or an open-price contract. As shown by Propositions 1 and 2 above, what does change across contract forms is S's ex ante investment a, and hence the ex post realized value creation for M, $q(a)$, and the size of M's loss from S's opportunism, $\beta(a)$.

It follows from the above analysis that a closed-price contract has both a benefit, given by a lower ex post dilution of M's pre-existing resources due to S's opportunism ($\beta(a^O) > \beta(a^C)$), as well as a cost, given by a parallel decrease in the value created within the relationship between M and S ($q(a^O) > q(a^C)$) and in the value obtained by S from expropriating and exploiting M's resources ($\pi(a^O) > \pi(a^C)$). When the benefit is larger than the cost, a closed-price contract will be more efficient – hence more likely to be used – than an open-price contract. Formally, this will be the case if, and only if, $JS(a^C) > JS(a^O)$, or

$$[\beta(a^O) - \beta(a^C)]\omega + (a^O - a^C) > [q(a^O) - q(a^C)] + [\pi(a^O) - \pi(a^C)]. \quad (6)$$

In words, a closed-price contract is more efficient for the relationship than an open-price contract when the "protection" a closed-price contract grants to M's pre-existing resources, measured by $[\beta(a^O) - \beta(a^C)]\omega$, plus the saving in S's investment cost, $a^O - a^C$, outweighs the lower level of value creation, measured by $[q(a^O) - q(a^C)]$, and the supplier's reduced private benefit from appropriation of M's resources, measured by $[\pi(a^O) - \pi(a^C)]$.

Proposition 3: A closed-price contract generates a higher joint surplus than an open-price contract when the value of M's pre-existing resources, ω, is high enough.

Proof: In appendix.

It is worthwhile to note that, if M's pre-existing resources were not exposed to S's ex post opportunism ($\beta_a = \pi_a = 0$), as normally assumed in the classic holdup and incomplete contracting models in the property rights tradition (e.g., Hart and Moore 1988), condition (6) would not hold because the closed-price investment would be zero and the open-price investment would be lower than the first best one. Hence, a closed-price contract would never be efficient because, absent ex post opportunism, its only effect would be to mute S's incentives to invest ex ante, thus generating an even more severe underinvestment problem than under an open-price contract (Che and Hausch 1999).[6] By the same argument, it should be noted that unlike in our model, in a standard holdup model without expropriable pre-existing resources, it would never be in M's and S's interest to choose a contract that reduces the value produced within the relationship. In contrast, in our model, under some conditions M and S could choose a contract that reduces the value generated in the particular relationship and it is precisely this aspect that will enable us to empirically distinguish our theoretical explanation for the use of closed-price versus open-price contracts from that provided in the existing transaction cost and property rights literatures.

[6] As shown by Che and Hausch (1999), this result holds whenever the seller invests mainly to create value for the end-product of the buyer. They call this type of productive investment "cooperative." See also MacLeod and Malcomson (1993).

4. Data and Context

4.1 Empirical context

We test our theoretical predictions on proprietary OEM-supplier agreements for engineered components that are incorporated into a variety of industrial products like machinery and equipment. The context of engineered components is well suited to test our theory for several reasons. First, many OEMs of industrial products source components and sub-systems through non-integrated supply chains; hence, procurement contracts are the more prevalent form of governance in these sectors than hierarchies. Second, suppliers are often required to engineer their components to be physically integrated into OEM's end product, which requires the supplier to make substantial dedicated investments. Finally, although the industrial firms in our sample all engage in procuring engineerted components, they show considerable variation in both contract forms and transaction characteristics.

4.2 Data collection procedure

We first conducted a series of on-site, in-depth interviews with purchasing managers of OEMs to ensure that our theoretical concepts were material in these settings. Based on these interviews and previously published studies, we developed a pilot questionnaire and administered it to purchasing managers at 18 OEMs to verify appropriate wording, response formats, and clarity of the instructions. Based on their feedback, we made appropriate changes.

Our unit of analysis is a procurement agreement between an OEM and its independent supplier for the supply of a component, or a set of technologically indivisible components integrated into a sub-system, 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; hence joint ventures and other equity arrangements are excluded from our analysis.

To identify key informants on the procurement agreements of interest, we drew a random sample of 1016 names of purchasing managers and directors in industrial engineering firms from a national mailing list. We then used the key informant procedure (Campbell 1955) to contact and qualify these informants. Multiple telephone calls using a snowball technique were necessary to qualify an informant at each firm. Each informant was asked to provide information on a particular component procurement agreement between their firm and the component supplier. To encourage participation, we offered them a customized report that summarized the relationship profiles in our sample and compared their own relationship with the average profile. We also set up a Web-based discussion forum for participants to comment on the reports and interact with other participants. Our qualification process yielded 521 informants to whom we mailed questionnaires and stamped, addressed envelopes. After using reminder cards and follow-up telephone calls and removing responses because of excessive missing data, we obtained a final sample of 155 responses. Our response rate of almost 30% is similar to the ones obtained in previous studies in similar industrial settings (e.g., Heide and John 1990).

4.3 Measures

We provide below a description of our measures of the theoretical constructs in our model. Table 1 describes the measures and provides the summary statistics. Table 2 shows their pairwise correlations.

<INSERT TABLE 1 AND TABLE 2 ABOUT HERE>

Main Variables

Contract form: We asked our informants to describe the price formats used in this particular contract. Our measures were adapted from previous work by Crocker and Reynolds (1993), Ghosh and John (2005), and Lo et al. (2012). Accordingly, we classified *closed-price contracts* as those agreements in which the OEM and the supplier agreed to either a fixed price or a price formula that is adjustable but only per some verifiable criteria (e.g. based on inflation in commodity prices, producer price index, etc.). Closed-price contracts hence pre-determine the distribution of trade surplus over the length of the contract. We classified *open-price contracts* as those that either did not specify a specific price ahead of shipment, or did specify a price but allowed for *negotiated* adjustments ex post. Under such open-price contracts, the distribution of trade surplus is determined ex post. *Contract form* is coded as a binary variable, with closed-price contracts and open-price contracts being assigned a value of 1 and 0 respectively.

OEM's pre-existing resources and capabilities: We measured the OEM's pre-existing resources and capabilities in two ways. Our main measure is a single item, 7-point scale that measures how much customer value the OEM's end product commands over competing products (*OEM product strength*). Consistent with our theoretical construct, this variable, adapted from Ghosh and John (2005), directly measures how strong customers perceive the OEM's product to be , compared to the products of its focal competitors, and hence constitutes a measure of the OEM's pre-existing endowment. Our second measure is the *OEM's market share* in its end product market. This variable again indexes the strength of the OEM's customer base. It may, nevertheless, also relate to factors such as market structure and government regulations that are not modeled by us. As such, we use it as a secondary measure to check the robustness of our results.

Supplier's dedicated investment: We asked the purchasing manager of the OEM to estimate the total dollar value of his component supplier's equipment and training expenditures dedicated to facilitate the procurement of the relevant component, choosing from 7 rank-ordered intervals (from less than $10,000 to over $2.5 millions). We use the 7 rank-ordered intervals as the ordinal measure of the supplier's dedicated investments.

Value-added to OEM's end product: To measure the value added generated within the OEM-supplier relationship, we asked our respondents to rate on a 7-point scale the extent to which the component procured under the said relationship has increased the sales of OEM's end-product (*End-product sales increase*).

Other Variables

The choice between closed and open price terms as well as the supplier's dedicated investments may also depend on variables that are not included in our theoretical model. First, since it is the supplier who mainly incurs these dedicated investments, the supplier would prefer a closed-price contract to safeguard its investment from the OEM if it could be easily replaced ex post (Klein et al. 1978; Masten 1988).

Hence, closed-price contracts may be more frequently observed when the supplier's ex post bargaining power is low. To control for the suppliers' ex post bargaining power, we use *Supplier irreplaceability*, which measures the number of months it would take the OEM to replace the current supplier with a new one. Similarly, when the OEM's ex ante bargaining power (i.e., its bargaining power before entering a relationship with a particular supplier) is high, it may use its bargaining power and seek a closed-price contract to commit the supplier to a firm, and lower, price. To control for the OEMs' ex ante bargaining power, we construct a measure called *OEM's relative size* – which is the ratio of the OEM's sales volume over all products to the supplier's sales volume over all products.

Second, the desirability of closed-price contracts, and the level of suppliers' dedicated investments, may depend on the extent to which price terms are contractible. As such, parties might stipulate closed-price contracts when they perceive that the formal contracts are enforceable by courts. We measured this using a 7-point item *Contract enforceability*, which we expect to be positively correlated with the use of closed-price contracts.

Several papers adopting the TCE framework have argued that fixed-price contracts are less useful in uncertain and complex environments where the terms of trade need to be adapted and modified in the course of the contractual relationship (Crocker and Reynolds 1993; Bajari and Tadelis 2001; Lo et al. 2012). As such, we include *Technological uncertainty*, which measures the unpredictability of the technology involved in the development of the component, and *Interface complexity*, which measures the complexity of the interface between the component and the end product. We also include *Norm of flexibility*, a 7-point item that measures how flexible the parties are in making adjustments to cope with possible changes in the environment. This variable has been shown to be important in industrial contexts (e.g., Heide and John 1990).

Furthermore, OEMs and suppliers may be more cooperative if they have dealt with each other in the past and hence are more likely to be in a long-term relationship that relies on self-enforcing agreements. This may induce them to choose formal price terms that facilitate self-enforcement (e.g., Klein and

Murphy 1988; Corts and Singh 2004). To control for such relationship duration, we use *Tenure*, which measures the accumulated duration of the parties' relationship, in number of years.

We did not include a measure of how much harm is caused to the OEM's capabilities due to the opportunistic use of the acquired knowledge by the supplier. In our model, the supplier's ex post opportunism (in terms of using the knowledge to develop its own end-products or develop components for a competitor's product) is likely to occur after the completion of the existing OEM-supplier transaction (Arruñada and Vázquez 2006; Alcacer and Oxley 2014). Therefore, our OEM manager informants were unlikely to directly observe the supplier's realized opportunism when they responded to our survey instrument. However, we expect these managers to have the foresight that their pre-existing endowments are potentially at risk of appropriation in such supplier ties and hence we expect them to choose governance forms that balance these hazards against the value-generating potential of the supplier relationship.

5. Results

5.1 Estimation Approach

The two hypotheses that we test are: (i) closed-price contracts should be used *more* when the OEM has high customer strength (Proposition 3), and (ii) *both* the supplier's dedicated investment and the value-added to OEM's end product from the relationship should be *lower* under a closed-price contract than under an open-price contract (Propositions 1 and 2). Evidence consistent with the two hypotheses points against a standard holdup or property rights model. Recall that in those models, dedicated investments have the sole effect of increasing value created within the relationship, but have no ex post harmful effects, for in that case a closed-price contract that reduces the value-added in the relationship would not be in the parties' interest.

Since contract form is an endogenous decision variable, Propositions 2 and 3 should not be tested by simply regressing *Supplier's dedicated investment* and *OEM's sales increase* on *Contract form*, because we would have biased and inconsistent estimates (Heckman 1978; Lee 1978; Shaver 1998). Having full data on outcomes – that is, supplier's dedicated investment and OEM's end-product sales increase – under *both* contract forms, we use the endogenous-switching regression approach to correct for the endogeneity of contract choice (Maddala 1983; Wooldridge 2010, pp.948-951). In particular, our empirical model is formulated as a system of the following two equations:

$$C_i^* = z_i^{'}\alpha + \gamma\omega_i + v_i \,, \qquad (7)$$

is a probit model named the "switching equation," whose dependent variable C_i takes value 1 if $C_i^* > 0$, and value zero otherwise, and

$$y_i^* = x_i^{'}\alpha + \lambda\omega_i + \theta C_i + u_i \,, \qquad (8)$$

is an ordered-probit model named the "outcome equation," whose dependent variable y_i takes value $y_i = 1$ if $-\infty < y_i^* < k_1$, $y_i = 2$ if $k_1 < y_i^* < k_2$, …, $y_i = 7$ if $k_7 < y_i^* < \infty$, where k_1,…, k_7 are threshold parameters.

In the contract-choice, or switching, equation (7), C_i is the dummy variable for *Contract form* (closed-price contract = 1; open-price contract = 0), ω_i is a measure of the OEM's pre-existing resources (measured two ways by *OEM product strength* and *OEM's market share*), the vector of regressors z_i includes *Tenure*, *Technological uncertainty*, *Interface complexity*, *Contract enforceability*, *Norm of flexibility*, *OEM's relative size*, and *Supplier irreplaceability*, and γ and α coefficients to be estimated.

In the outcome equation (8) where we use the ordered probit technique, y_i is the ordinal variable of relationship outcomes – *Supplier's dedicated investment* and *OEM's sales increase*, x_i is a vector of regressors that includes all the variables in z_i from the contract choice equation, except for instrument - *Contract enforceability*, and α , λ , and θ are coefficients to be estimated. As discussed earlier, enforceability of formal contracts directly affects the choice of price terms. However, typical contracts in component purchase are of standard format ("boilerplate") and do not specify ex ante the dedicated investments and their levels to be made by the supplier. This is because those investments are of an ongoing nature and are mostly non-contractible (see also Ghosh and John 2005). Similarly, these contracts do not specify the sales increase outcomes, despite the fact that they may stipulate some technical requirements in the component or sub-system being procured. These facts make *Contract enforceability* a reasonable instrumental variable for *Contract form*.[7]

Furthermore, the two error terms, u_i and v_i, are assumed to have a bivariate normal distribution, and the level and statistical significance of their correlation coefficient, ρ, indicates whether contract form, C_i, is endogenous in equation (8). We estimate the endogenous switching regression of (7) and (8) jointly using the full-information maximum-likelihood (FIML) method specified in Miranda and Rabe-Hesketh (2006).

While we have attempted our best to control for the endogeneity of contract form, the cross-sectional nature of our data limits our claims in terms of establishing causality in the relationship among OEM's pre-existing resources and capabilities, contract form, and relationship outcomes (i.e., supplier's dedicated investments and OEM's sales increase). Thus, our empirical approach should be looked at as presenting robust correlations among these variables that are consistent with our theory of contracts as means to safeguard pre-existing resources that cannot be easily reconciled with alternative theoretical explanations.

5.2 Estimation Results

We first present the results on the effect of contract form on supplier's dedicated investment and OEM's end-product sales increase using ordered probit *without* correcting for the endogeneity of contract form. We then compare the results from these "naïve" regressions to those from the endogenous switching regressions in which contract form is endogenous. For the endogenous switching regressions, we present

[7] Note that having excluded independent variables in the outcome equations is desirable but not necessary for identification purposes (Wooldridge 2010, p.806). In unreported regressions, available upon request, we include as a robustness check *Contract enforceability* in both equations (7) and (8), which are thus solely identified by their nonlinear functional form. We obtain results that are qualitatively similar to those presented here.

two sets of results: (1) the switching equations in which we investigate the determinants of contract form, and (2) the outcome equations in which we look at how contract form affects the level of supplier's dedicated investment and value added to OEM's end product in terms of sales increase. Recall from Section 4 that in all regressions, we use *OEM product strength* and *OEM's market share* as alternative measures of the OEM's pre-existing resources and capabilities.

Table 3 shows the results from the ordered probit estimation of the naïve version of the relationship between contract form and the outcomes. Columns 1 and 2 show the results from regressing *Supplier's dedicated investment* on *Contract form* and other variables for our two alternate measures of OEM's pre-existing resources and capabilities – *OEM product strength* (column 1) and *OEM's market share* (column 2). Similarly, columns 3 and 4 show the results for the *OEM's end-product sales increase* as the dependent variable.

<INSERT TABLE 3 ABOUT HERE>

We focus our observation on the effect of contract form on supplier's dedicated investment and OEM's sales increase. First, when we use *OEM product strength* to measure OEM's pre-existing resources and capabilities, closed-price contracts have no effect on *Supplier's dedicated investment* (column 1) and a negative but insignificant effect *OEM's sales increase* (column 3) respectively. When we use the alternative measure of *OEM's market share*, we find that closed-price contracts negatively impact the *Supplier's dedicated investment* (column 2) but have a statistically insignificant effect on *OEM's sales increase* (column 4). Given the effect of closed-price contracts on the suppliers' investment levels, one would also expect them to have a similar effect on the value-added to OEM's end-product. The results in Table 3 show no evidence of this. In fact, the coefficients of *Contract form* in columns 1 and 3, and those in columns 2 and 4, are of opposite signs, albeit most of them are not statistically significant.

We suspect that these inconsistencies and hard-to-explain results may be caused by the contract endogeneity problem. Hence, in the next set of analysis, we correct for this endogeneity of contract form by adopting the endogenous switching regression approach (Miranda and Rabe-Hesketh 2006; Wooldridge 2010).

Table 4 shows the results for the two sets of endogenous switching regressions when we use *OEM product strength* as the measure of the OEM pre-existing resources and capabilities. Columns 1 and 3 are the "switching equations" that provide the determinants of *Contract form* and columns 2 and 4 are the "outcome equations" for the *Supplier's dedicated investment* and the *OEM's sales increase* respectively. In Table 5 we provide similar results for our alternative measure of the OEM pre-existing resources and capabilities – the *OEM's market share*.

<INSERT TABLE 4 ABOUT HERE>

Consider Table 4. Columns 1 and 3 show the results for the determinants of *Contract form*. First and foremost, we find support for Proposition 3 in our data. The OEM's pre-existing resources and capabilities – measured by *OEM product strength* – are positively correlated with the adoption of closed-price contracts, with the coefficient of *OEM product strength* (γ = 0.30 and 0.21 respectively) being both positive and statistically significant. This is consistent with Proposition 3, according to which closed prices, but not open prices, are optimal contracts to safeguard vulnerable pre-existing capabilities (see also e.g., Lo et al. 2012).

We also find that many other variables influence the choice of contract form. When technology related to the component is highly unpredictable and fast evolving, open prices are more frequently used, perhaps because it is more difficult for the parties to specify the technology and hence determine ex ante the division of the trade surplus. At the same time, *Interface complexity* has a statistically insignificant effect on contract choice. As one would expect, data shows that open-price contracts are more likely to be used when being flexible to adapt to changing environments is the informal norm within the relationship, whereas closed-price contracts are more likely to be used when contractual enforceability is high. We also find that the length of parties' prior business relationship (i.e., Log(*Tenure*)) has no statistically significant effect on contract form.

As we explained earlier, parties' bargaining power may play a role in crafting their price terms. In the data we find that the OEM's ex ante bargaining power, measured by *OEM relative size,* has an insignificant effect on contract form. However, the supplier's ex post bargaining power, measured by *Supplier irreplaceability*, has a significant negative association with the use of closed prices. This is not surprising: the supplier is less exposed to the risk of OEM's holdup when he is unreplaceable, in which case he does not need to use closed-price formats to safeguard his dedicated investments but would put more focus on increasing value of the OEM's end product.

Columns 2 and 4 show our ordered-probit estimates for the outcome equation specified in (8). The dependent variable in column 2 is *Supplier's dedicated investment* and that in column 4 is *OEM's sales increase*.

Our data provides strong support for Proposition 1. We find that *Supplier's dedicated investments* are significantly lower under closed-price contracts than under open-price contracts (column 2, $\theta = -0.89$). This is consistent with our theoretical prediction that closed-price contracts *dis*-incentivize the provision of supplier's investment. We also find strong support for Proposition 2, which predicts that the value added by the supplier's component to the OEM's end-product should be smaller under a closed-price contract than under an open-price contract. The empirical results in column 4 show that the OEM's end-product sales increase is significantly lower under closed-price contracts than that under open-price contracts ($\theta = -1.29$).

Additional insights can be gleaned from the results in columns 2 and 4. Specifically we find that (a) both *Norm of flexibility* and *Supplier irreplaceability* are positively associated with both supplier's dedicated investment and OEM's sales increase, and (b) *OEM product strength*, *Technology uncertainty*, *Interface complexity*, *Tenure*, and *Relative size* are all positively associated with the supplier's dedicated investment but have no significant impact on the OEM's sales increase. The positive effect of technology uncertainty and interface complexity on dedicated investments are consistent with Bensaou and Anderson (1999)'s findings in automobile manufacturing.

Using the alternative measure for OEM's pre-existing resources – the *OEM's market share* – yields qualitatively similar results. These are shown in Table 5 where the results for the switching regressions (columns 1 and 3) show that *OEM's market share* is positively correlated with the adoption of closed-price contracts and the results in the outcome regressions (columns 2 and 4) show that closed-price contracts negatively correlate with both the supplier's dedicated investment and the OEM's sales increase. These results are again consistent with our three propositions and the robustness of these findings, across two different measures of OEM's pre-existing resources and capabilities, gives us confidence in our theoretical predictions as well as in the empirical results. Said otherwise, our results suggest that when choosing between closed-price and open-price contract forms, OEMs seem to undertake a "strategizing calculus" where they trade off the potential gains they could obtain from the relationship with their supplier (dedicated investments that enhance the value-add of the OEM's end-product) with the potential loss of their pre-existing, extra-relational endowments.

<INSERT TABLE 5 ABOUT HERE>

The effects of other variables in Table 5 are also qualitatively similar to those in Table 4. The only noticeable difference is that *Interface Complexity* is positively associated with closed-price contracts. One possible reason for this somewhat unexpected result is that interface complexity may force parties to undertake significant effort in understanding and specifying the technical features of the component and end-product interface. As a consequence of this process, parties might have a clearer idea on how to divide their trade surplus and this may facilitate their ability to agree on a price ex ante.

The empirical results suggest that controlling for the endogeneity of contract choice is important. First, the *Contract form* coefficients in the outcome equations in Tables 4 and 5 are significant, robust and consistent, while those in the "naïve" regressions from Table 3, where we did not correct for the endogeneity of contract choice, are not. Second, Tables 4 and 5 (bottom panels) show that the tests of contract endogeneity in our endogenous switching regressions, are significant in three out of the four cases (the p-value in Table 5's column 2 is 0.17, showing marginal significance).

Lastly, our theoretical model also assumes that the supplier's dedicated investment contributes to the value-added of the component to the OEM's end-product. To validate this assumption, we regress *OEM's end-product sales increase* on the predicted values of *Supplier's dedicated investment* generated from the outcome equations in columns 2 in Tables 4 and 5. Our assumption is supported by the results in Table 6, where dedicated investments and sales increase are positively related under both measures of OEM's pre-existing resources. Note that in these regressions, we use *Interface complexity* to instrument the latter because more complex interface should lead the supplier to invest more but should not have a direct impact on end-product sales increase. Indeed, this rationale is supported by the results shown in Tables 4 and 5 (see also the corresponding pairwise correlations in Table 2).

<INSERT TABLE 6 ABOUT HERE>

5.3 Remarks

As pointed out earlier, we do not have a direct measure of the actual harm caused to the OEM's pre-existing resources and capabilities due to the supplier's actions. Hence, we cannot offer direct evidence that closed-price contracts are being used to protect these pre-existing, extra-relational resources, which is one of our theoretical premises. However, the indirect evidence we present, which is consistent with our model's predictions, is hard to reconcile with existing theoretical approaches in contracting and governance design such as TCE, Property Rights Theory, and multi-task agency theory.

In the standard TCE model of holdup and post-contractual opportunism (e.g., Williamson 1979), the dedicated investments made by the suppliers are assumed to only have productive value; hence, choosing closed-price contracts that *reduce* the suppliers' dedicated investments would not be in the interest of OEMs and suppliers. In the Propert Rights Theory models of incomplete contracts (e.g., Grossman and Hart 1986; Hart and Moore 1988), both the OEM and the supplier may invest in the relationship, so a closed-price contract that incentivizes the OEM at the cost of dis-incentivizing the supplier may be optimal if the OEM's investment is more productive. However, Property Rrights Theory models would predict that under a contract that optimizes among the parties' productive investments, the OEM's end product sales should *increase*, which is inconsistent with our data. Finally, in a multi-task agency model (e.g., Holmstrom and Milgrom 1991; Slade 1996), it might be optimal to choose a closed-price contract that reduces the supplier's sales-enhancing effort, such as component customization, but increases his cost-reducing effort, provided that the latter is more important for the OEM. However, and inconsistent with the multitask logic, our data show that closed-price contracts are chosen when the OEM has high levels of pre-existing resources and capabilities and hence stands to lose more from a reduction in component customization and quality.

We thus conclude that the empirical evidence presented here supports our theoretical approach, according to which contractual price terms safeguard OEMs' pre-existing resources and capabilities, at the cost of reducing suppliers' dedicated investments and value creation within OEM-supplier collaborative relationships.

6. Conclusion

This paper has investigated the role of contracts in industrial sourcing relationships where the buyer (the OEM) brings pre-existing resources and capabilities while the seller (the component supplier) makes dedicated investments. We construct a simple game theoretical model where we assume that the seller's dedicated investments might not only serve the productive purpose of generating value within the relationship, but also serve the opportunistic purpose of expropriating the buyer's pre-existing resources. If these buyer's resources are valuable, the seller may have an incentive to *overinvest* ex ante so that the knowledge acquired in the investment process will enable him to expropriate the buyer's resources ex post. Our model shows that a contract that specifies the price ex ante *reduces* the seller's incentives to both overinvest and expropriate these extra-relational resources. However, because of the lower level of supplier's dedicated investment, this advantage of a closed-price contract comes at the cost of reducing the value creation within the focal relationship.

Data on 155 component procurement agreements support the hypotheses generated by our model. In particular, the data shows that OEMs use closed-price contracts when the value of their resources and capabilities – measured by their end-product market strength and market share – are high, and that *both* the supplier's dedicated investments *and* OEM's end-product sales are significantly lower under closed-price contracts than under open-price contracts. While consistent with our theory, these results cannot be predicted by alternative theoretical approaches in the contracting literature such as TCE, Property Rrights Theory, and multi-task agency theory.

In terms of managerial implications, our results provide clear guidance for OEMs when they bring valuable pre-existing resources, such as proprietary technologies, product development and design skills, and a strong downstream customer base (through strong brands) into their contractual relationships with component suppliers. Our key result suggests that OEM managers should act as "governance value engineers" (Gilson 1984) who add value by constructing contracts properly. Specifically, we suggest that these managers engineer contracts that balance (a) their expected gains from the value-added investments and customization within the relationship with (b) their expected losses borne out of exposing their pre-existing endowments, resources, and capabilities to potentially opportunistic actions on the part of the supplier.

At the same time, our results also offer important managerial advice to suppliers. In particular, how could a component supplier persuade an OEM, especially one with a large pre-existing resource profile, to enter into an open-price contract that enhances dedicated investments and leads to value creation? Our data show that norms of flexibility and difficulty to replace the supplier lead to more open prices. The first result implies that the supplier should build a reputation for being flexible to adapt to unforeseeable circumstances. The second result implies that by committing to the relationship, and hence making it hard for the OEMs to substitute him, the supplier may be able to "soften" contractual terms.

We conclude by discussing some limitations of our study and related implications for future work. First, the unit of our analysis is a contract and we use contract-level data from a survey instrument. We did our best to take necessary precautions to collect the data, but the fact that many of our key measures are perceptual might generate biases such as recall bias. Future studies involving additional direct and transactional data would help to resolve some of these concerns. Second, our hypotheses generate clear predictions on ex post appropriation but, as we explained earlier, we do not have direct evidence of such appropriation because of the time lag necessary to observe them. To comprehensively test this part of our theory, future studies would have to combine information on value creation within a relationship and longer term expropriation activities external to the relationship (e.g., Alcacer and Oxley 2014). Third, our analysis focuses on the indirect role of price terms – via investment dis-incentives – in protecting buyers' pre-existing resources. As we mentioned, companies also use explicit clauses such as exclusive contracts and intellectual property laws as safeguarding mechanisms. It would be fruitful to investigate their roles, both separately from and interactively with the price formats, in such contexts. Lastly, in many other industrial contexts such as automobile and jet manufacturing, and information technology service and solutions markets, both the OEM and its key suppliers may jointly invest to develop their product offerings to end customers. It is typical also for both parties to bring vulnerable pre-existing resources and capabilities into their relationships – for instance, proprietary, state-of-the-art technology in a specific domain by the supplier and an integrative, value-enhancing architecture based on in-depth customer knowledge by the OEM. Future theoretical and empirical investigations on more complex alliances will need to provide insights on how firms design and manage their governance arrangements in such "two-sided" scenarios.

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FIGURE 1: TIMELINE OF EVENTS

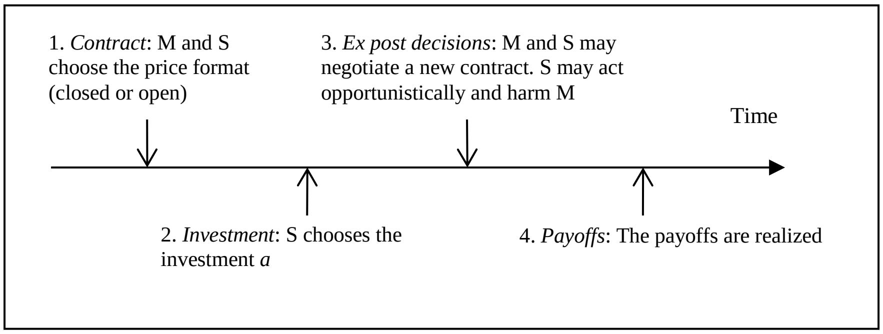

TABLE 1: MEASURES AND DESCRIPTIVE STATISTICS

Variable	Measure	Mean	S.D.	Min.	Max.
Contract form (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	0.38	0	1
Supplier's dedicated investment	Estimate the total dollar value (over all fiscal periods) of this supplier's expenditure for equipment, training, etc. dedicated to facilitating your procurement of the identified item(s). Choose one from: (1) Less than $10,000; (2) $10,000 - $24,999; (3) $25,000 - $99,999; (4) $100,000 - $499,999; (5) $500,000 - $999,999; (6) $1,000,000 - $2,499,999; (7) $2,500,000 or more.	3.48	1.42	1	7
OEM end-product sales increase	This relationship has helped boost the sales of our end-product. (1-7 single-item scale)	3.99	1.65	1	7
OEM's market share (100%)[†]	What market share for this type of end-product(s) is accounted for by your end-product line? __ % market share held by our end-product(s).	0.22	0.15	0.02	0.90
OEM product strength	Customers value our end-product more than competing products. (1-7 single-item scale)	4.52	1.54	1	7
Tenure[†]	How long has your business unit had a business relationship with this supplier? (year)	8.14	4.91	1	25
Technological uncertainty	Technological developments related to this item are very unpredictable. (1-7 single-item scale)	2.72	1.29	1	7
Interface complexity	Item has a complex interface with other components in the end-product. (1-7 single-item scale)	4.68	1.32	1	7
Contract enforceability	The terms of our formal contract can be readily enforced in court, if necessary. (1-7 single-item scale)	3.834	1.35	1	7
Norm of flexibility	It is expected that parties will make adjustments in the ongoing relationship to cope with changing circumstances	4.51	1.16	1	7
OEM's relative size[†]	With respect to your last year's sales volume over all products, how large is your firm relative to this supplier?	7.22	14.94	0.01	100
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 switch-over 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 to 3 months; (3) 4 to 6 months; (4) 7 to 9 months; (5) 10 to 12 months; (6) 13 to 24 months; (7) Over 24 months.[#]	3.25	3.21	0.5	18.5

Number of observations = 155.
[†]We use natural log of these variables in our estimations. [#] We take the mid-point value of each interval as the actual number of months. For the highest tier, we assume 30 months.

TABLE 2: CORRELATIONS TABLE

		1	2	3	4	5	6	7	8	9	10	11	12
1	*Contract form* (Closed-price=1; otherwise=0)	-											
2	*Supplier's dedicated investment*	0.02	-										
3	*End-product sales increase*	-0.29***	0.31***	-									
4	*OEM market share*	0.11	0.18**	0.19**	-								
5	*OEM product strength*	0.22***	0.39***	0.05	0.45***	-							
6	*Tenure*	0.09	0.03	-0.13	0.15*	0.05	-						
7	*Technological uncertainty*	-0.18**	0.26***	0.32***	0.17*	0.14*	-0.24***	-					
8	*Interface complexity*	0.04	0.29***	0.13	0.10	0.23***	-0.19**	0.20***	-				
9	*Contract enforceability*	0.23***	0.02	-0.33***	0.21**	0.11	0.22***	-0.09	-0.16**	-			
10	*Norm of flexibility*	-0.17**	0.09	0.34***	-0.05	-0.12	-0.21***	-0.07	-0.03	-0.10	-		
11	*OEM's relative size*	-0.03	0.15*	0.05	0.21***	0.26***	-0.15*	0.08	-0.04	0.01	-0.22***	-	
12	*Supplier irreplaceability*	-0.20**	0.40***	0.45***	0.17**	0.13	0.01	0.35***	0.21***	-0.12	0.27***	0.06	-

Number of observations = 155. *** significant at 0.01; ** significant at 0.05; * significant at 0.10.

TABLE 3: EFFECT OF CONTRACT FORM ON RELATIONSHIP OUTCOMES WITHOUT CORRECTING FOR CONTRACT ENDOGENEITY
(ordered probit)

	Supplier's productive investment		*OEM's end-product sales increase*	
	1	2	3	4
Main variables				
Contract form	0.06	-0.39*	-0.34	0.16
(Closed-price=1; otherwise=0)	(0.19)	(0.22)	(0.23)	(0.20)
OEM product strength	0.18***		0.05	
	(0.06)		(0.06)	
Log(*OEM's market share*)		0.40***		0.17
		(0.12)		(0.14)
Other variables				
Log(*Tenure*)	0.30**	-0.15	-0.09	0.32**
	(0.13)	(0.12)	(0.11)	(0.14)
Technological uncertainty	0.14*	0.17**	0.18**	0.15*
	(0.08)	(0.08)	(0.08)	(0.08)
Interface complexity	0.21**	0.00	-0.01	0.25***
	(0.08)	(0.07)	(0.08)	(0.07)
Contract enforceability	0.06	-0.25***	-0.22***	0.07
	(0.07)	(0.08)	(0.08)	(0.08)
Norm of flexibility	0.15*	0.34***	0.32***	0.15*
	(0.08)	(0.08)	(0.08)	(0.08)
OEM's relative size	0.16***	0.02	0.05	0.17***
	(0.04)	(0.04)	(0.04)	(0.05)
Log(*Supplier irreplaceability*)	0.26***	0.29***	0.33***	0.25**
	(0.10)	(0.11)	(0.11)	(0.10)
Wald χ^2 statistic	84.04***	62.57***	57.39***	78.62***

Number of observations = 155 with 127 closed-price contracts (coded as 1) and 28 open-price contracts (coded as 0). Robust t-statistics in parentheses. Two-tail test: *** significant at 0.01; ** significant at 0.05; * significant at 0.10. For brevity, results of threshold cuts are omitted.

TABLE 4: THE CHOICE OF CONTRACT FORM AND ITS EFFECT ON OUTCOMES
Using measure of OEM's pre-existing resource: *OEM product strength*
(Endogenous Switching Regressions)

	Supplier's dedicated investment		*OEM's end-product sales increase*	
	1	2	3	4
	Contract form: *Closed-price contract* = 1; *Open-price contract* = 0 (Switching equation: Probit)	*Supplier's dedicated investment* (Outcome equation: Ordered Probit)	*Contract form*: *Closed-price contract* = 1; *Open-price contract* = 0 (Switching equation: Probit)	*OEM's end-product sales increase* (Outcome equation: Ordered Probit)
Main variables				
Contract form		-0.89***		-1.29***
(Closed-price=1; otherwise=0)		(0.16)		(0.29)
OEM product strength	0.30***	0.28***	0.21**	0.08
	(0.08)	(0.04)	(0.10)	(0.06)
Other variables				
Log(*Tenure*)	0.14	0.35***	-0.01	-0.12
	(0.16)	(0.07)	(0.20)	(0.12)
Technological uncertainty	-0.19*	0.10**	-0.20*	0.13
	(0.10)	(0.04)	(0.11)	(0.08)
Interface complexity	0.13	0.12***	0.18	0.04
	(0.10)	(0.04)	(0.12)	(0.07)
Norm of flexibility	-0.25**	0.08*	-0.17	0.29***
	(0.11)	(0.04)	(0.14)	(0.08)
Log(*OEM's relative size*)	0.04	0.14***	0.00	0.05
	(0.07)	(0.05)	(0.07)	(0.04)
Log(*Supplier irreplaceability*)	-0.37**	0.26***	-0.45**	0.24**
	(0.17)	(0.05)	(0.21)	(0.11)
Contract enforceability	0.17*		0.30***	
	(0.10)		(0.10)	
Constant	0.09		-0.10	
	(0.89)		(1.12)	
Test for endogeneity of *Contract from* (H_0: ρ=0): χ^2 statistic	5.36**		1.85	
Wald χ^2 statistic	492.59***		147.07***	

Columns 1 and 2 represent one set of endogenous switching regression jointly estimated by FIML method . Similarly for Columns 3 and 4.
Number of observations = 155 with 127 closed-price contracts and 28 open-price contracts. Robust standard errors in parentheses. Two-tail test: *** significant at 0.01; ** significant at 0.05; * significant at 0.10. For brevity, results of threshold cuts are omitted.

TABLE 5: THE CHOICE OF CONTRACT FORM AND ITS EFFECT ON OUTCOMES
Using measure of OEM's pre-existing resource: *OEM's market share*
(Endogenous Switching Regressions)

	Supplier's dedicated investment		*OEM's end-product sales increase*	
Model	1	2	3	4
	Contract form: *Closed-price contract* = 1; *Open-price contract* = 0 (Switching equation: Probit)	*Supplier's dedicated investment* (Outcome equation: Ordered Probit)	*Contract form*: *Closed-price contract* = 1; *Open-price contract* = 0 (Switching equation: Probit)	*OEM's end-product sales increase* (Outcome equation: Ordered Probit)
Main variables				
Contract form		-0.84***		-1.43***
(Closed-price=1; otherwise=0)		(0.27)		(0.34)
OEM's market share	1.23*	-0.45	1.02[#]	1.47***
	(0.67)	(0.38)	(0.80)	(0.55)
Other variables				
Log(*Tenure*)	0.24	0.52***	0.00	-0.16
	(0.24)	(0.16)	(0.23)	(0.15)
Technological uncertainty	-0.18	0.18	-0.20	0.11
	(0.13)	(0.14)	(0.12)	(0.10)
Interface complexity	0.30***	0.32***	0.24**	0.05
	(0.11)	(0.08)	(0.11)	(0.07)
Norm of flexibility	-0.32**	-0.01	-0.17	0.27**
	(0.13)	(0.09)	(0.14)	(0.11)
Log(*OEM's relative size*)	0.08	0.20**	0.03	0.04
	(0.08)	(0.08)	(0.07)	(0.04)
Log(*Supplier irreplaceability*)	-0.48*	0.11	-0.45**	0.21*
	(0.25)	(0.15)	(0.21)	(0.11)
Contract enforceability	0.15		0.31***	
	(0.10)		(0.09)	
Constant	0.71		0.26	
	(1.24)		(1.25)	
Test for endogeneity of *Contract from* (H_0: ρ=0): χ^2 statistic	4.98**		4.12**	
Wald χ^2 statistic	239.49***		185.84***	

Columns 1 and 2 represent one set of endogenous switching regression jointly estimated by FIML method . Similarly for Columns 3 and 4.
Number of observations = 155 with 127 closed-price contracts and 28 open-price contracts. Robust standard errors in parentheses. Two-tail test: *** significant at 0.01; ** significant at 0.05; * significant at 0.10. One-tail test: [#] significant at 0.05. For brevity, results of threshold cuts are omitted.

TABLE 6: THE EFFECT OF SUPPLIER'S DEDICATED INVESTMENT ON OEM'S END PRODUCT SALES INCREASE (Ordered Probit)

	OEM's end-product sales increase	
Model	1	2
Main variable		
Predicted *Supplier's dedicated investment*	0.48**	0.27#
	(0.24)	(0.17)
Other variables		
OEM product strength	-0.11	
	(0.08)	
OEM's market share		1.09*
		(0.56)
Log(*Tenure*)	-0.31**	-0.31**
	(0.13)	(0.14)
Technological uncertainty	0.12	0.11
	(0.09)	(0.09)
Norm of flexibility	0.29***	0.35***
	(0.08)	(0.08)
Log(*OEM's relative size*)	-0.01	-0.01
	(0.05)	(0.05)
Log(*Supplier irreplaceability*)	0.21	0.30**
	(0.14)	(0.12)
Wald χ^2 statistic	57.98***	62.26***

Predicted values of *Supplier's dedicated investment* in columns 1 and 2 are obtained, respectively, from the outcome equations in columns 2 in Tables 4 and 5. *Supplier's dedicated investment* is instrumented by *Interface complexity*. Robust standard errors in parentheses. Two-tail test: *** significant at 0.01; ** significant at 0.05; * significant at 0.10. One-tail test: # significant at 0.05. For brevity, results of threshold cuts are omitted.

Appendix: Mathematical proofs

Lemma: Relative to the first-best level, under an open-price contract, S's investment is inefficiently low ($a^O < a^{FB}$) at low levels of ω and inefficiently high ($a^O > a^{FB}$) at high levels of ω.

Proof: The proof consists of three results. First, we prove that the first-best investment, a^{FB}, decreases in ω. Second, we prove that the open-price investment, a^O, does not depend on ω. Third, we prove that $a^{FB} > a^O$ at $\omega = 0$. Combined together, these three results imply that there must be a critical level of ω above which a^{FB} becomes smaller than a^O.

Result I: a^{FB} decreases in ω: Recall that the first best investment level is

$$a^{FB} = argmax_a\{JS(a)\} = argmax_a\{q(a) + \pi(a) + [1 - \beta(a)]\omega - a\}. \quad \text{(A1)}$$

By assumption, $q(a)$, $\pi(a)$, and $\beta(a)$ are concave functions, so $JS(a)$ is also concave. Hence, the first-order condition for program (A1) is both necessary and sufficient for a^{FB} to be a global maximum. The first-order condition is given by

$$q_a(a^{FB}) + \pi_a(a^{FB}) - \beta_a(a^{FB})\omega - 1 = 0. \quad \text{(A2)}$$

Differentiating (A2) with respect to ω, we have

$$[q_{aa}(a^{FB}) + \pi_{aa}(a^{FB}) - \beta_{aa}(a^{FB})\omega]\frac{\partial a^{FB}}{\partial \omega} - \beta_a(a^{FB}) = 0. \quad \text{(A3)}$$

Rearranging (A3) with respect to $\frac{\partial a^{FB}}{\partial \omega}$, we obtain

$$\frac{\partial a^{FB}}{\partial \omega} = \frac{\beta_a(a^{FB})}{q_{aa}(a^{FB}) + \pi_{aa}(a^{FB}) - \beta_{aa}(a^{FB})\omega}. \quad \text{(A4)}$$

The expression in (A4) is negative because $\beta_a(\cdot) > 0$ by assumption, and $q_{aa}(a^{FB}) + \pi_{aa}(a^{FB}) - \beta_{aa}(a^{FB})\omega < 0$ due to our assumptions that M's value function is concave ($q_{aa}(\cdot) < 0$) and that the net joint payoff from S's appropriation is also concave ($\pi_{aa}(\cdot) - \beta_{aa}(\cdot)\omega < 0$).

Result II: a^0 does not depend on ω: Recall that the open-price investment level is

$$a^O \equiv argmax_a\left\{U_S^O(a) - a = \pi(a) + \frac{1}{2}q(a) - a\right\}. \quad \text{(A5)}$$

Since the maximand in (A5)—that is, the function between brackets on the right-hand side —does not depend on ω, the solution to the maximization problem does not depend on ω either, that is, $\frac{\partial a^O}{\partial \omega} = 0$.

Result III: $a^{FB} > a^O$ at $\omega = 0$: at $\omega = 0$, the first-order condition for a^{FB}, given by (A2) above, becomes

$$q_a(a^{FB}) + \pi_a(a^{FB}) - 1 = 0. \quad \text{(A6)}$$

The first-order condition for a^O, obtained by differentiating the maximand in (A5) and equating it to zero, is

$$\frac{1}{2} q_a(a^O) + \pi_a(a^O) - 1 = 0. \quad \text{(A7)}$$

For a given a, the left-hand side of (A6) is larger than the left-hand side of (A7). This implies that the left-hand side of (A6), evaluated at a^O, is larger than zero. The functions $q(\cdot)$ and $\pi(\cdot)$ are concave by assumption, so the left-hand side of (A6) is decreasing in a. This implies that if $a = a^O$, the first-best investment level is reached by increasing a until the left-hand side of (A6) drops to zero. In other words, it must be that $a^{FB} > a^O$ at $\omega = 0$.

Conclusion: we have proved that $a^{FB} > a^O$ at $\omega = 0$ (result III) and that increasing ω reduces a^{FB} (result I) without affecting a^O (result II). Since a^{FB} is a continuous function of ω, this implies that there must be $\omega^* > 0$ such that $a^{FB} > a^O$ for $\omega < \omega^*$ and $a^{FB} < a^O$ for $\omega > \omega^*$. This proves the Lemma. QED.

Proposition 1: A closed-price contract induces the supplier to invest less than under an open-price contract ($a^O > a^C$).

Proof: Under an open price contract, the necessary and sufficient first order condition for S's investment choice problem is given by (A7) above. Under a closed price contract, S's investment level is

$$a^C \equiv argmax_a\{\pi(a) + p - a\}^C. \quad \text{(A8)}$$

The necessary and sufficient first-order condition for this problem is

$$\pi_a(a^C) - 1 = 0. \quad \text{(A9)}$$

For a given a, the left-hand side of (A7) is larger than the left-hand side of (A9). This implies that the left-hand side of (A7), evaluated at a^C, is larger than zero. The functions $q(\cdot)$ and $\pi(\cdot)$ are concave by assumption, so the left-hand side of (A7) is decreasing in a. This implies that if $a = a^C$, under an open price contract S reaches his preferred investment level by increasing a until the left-hand side of (A7) drops to zero. In other words, it must be that $a^O > a^C$. QED.

Proposition 2: M's value added from incorporating S's component into the end product is larger under an open-price contract than that under a closed-price contract ($q(a^O) > q(a^C)$).

Proof: By assumption M's value function $q(\cdot)$ is increasing in a, implying that $q(a') > q(a)$ for any $a' > a$. We have shown in proposition 1 that $a^O > a^C$, so this implies that $q(a^O) > q(a^C)$. QED.

Proposition 3: A closed-price contract generates higher joint surplus than an open-price contract when the value of M's pre-existing resources, ω, is high enough.

Proof: The proof consists of two results. First, we show that at $\omega = 0$, the joint surplus is higher under an open-price contract than under a closed-price contract ($JS(a^C) - JS(a^O) < 0$). Second, we show that the difference between the joint surpluses under a closed-price and an open-price contract ($JS(a^C) - JS(a^O)$) increases in ω so that there must be a critical level of ω above which the joint surplus under a closed-price contract becomes higher than under an open-price contract.

Result I: $JS(a^C) - JS(a^O) < 0$ at $\omega = 0$. At $\omega = 0$, the joint surpluses under an open-price and closed-price contract are, respectively

$JS(a^O) = q(a^O) + \pi(a^O)$, and (A10)

$JS(a^C) = q(a^C) + \pi(a^C)$. (A11)

We have proved in the Proposition 1 that $a^O > a^C$. Since both $q(\cdot)$ and $\pi(\cdot)$ are increasing in a by assumption, this implies that $\Delta JS \equiv JS(a^C) - JS(a^O) < 0$ at $\omega = 0$.

Result II: $JS(a^C) - JS(a^O)$ increases in ω. Rearranging the left-hand side in condition (6), we can write ΔJS as

$$[\beta(a^O) - \beta(a^C)]\omega + (a^O - a^C) - [q(a^O) - q(a^C)] - [\pi(a^O) - \pi(a^C)]. \quad \text{(A12)}$$

We have proved in the Lemma that a^O does not depend on ω. By an indentical argument, a^C is also independent of ω. Hence, differentiating (A12) with respect to ω we obtain

$$\frac{\partial \Delta JS}{\partial \omega} \equiv \beta(a^O) - \beta(a^C). \quad \text{(A13)}$$

Since we have shown in Proposition 1 that $a^O > a^C$ and $\beta(\cdot)$ is increasing in a by assumption, the right-hand side of (A13) must be positive, that is, $\frac{\partial \Delta JS}{\partial \omega} > 0$.

Conclusion: we have proved that $\Delta JS < 0$ at $\omega = 0$ (result I) and that $\frac{\partial \Delta JS}{\partial \omega} > 0$ (result II). Since ΔJS is a continuous function of ω, this implies that there must be $\omega^{**} > 0$ such that $\Delta JS < 0$ for $\omega < \omega^{**}$ and $\Delta JS > 0$ for $\omega > \omega^{**}$. QED.