PRODUCT PERFORMANCE AND CONTRACTS:

THEORY AND EVIDENCE

Product Performance and Contracts in Multi-component System Industries: Theory and Evidence

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Abstract

This dissertation will investigate how Product Performance Contracts are organized in Multi Component Systems contexts that proliferate contemporary OEM industries. The last two decades have seen a big change in both practice as well as the product engineering technologies that form the ecosystem within which suppliers and buyers negotiate the scale and scope of their transaction contracts. While we have seen the focus of industrial procurement move from specifications based contracts to performance based contracts, we are also witnessing a burgeoning technological capability that allows remote monitoring of product performance. These capabilities are part of the interconnectivity driving the much-touted Internet of Things (IoT) technology and at the heart of the Industrial Big Data ecosystem. The dissertation will attempt to explain three major phenomena in the industrial buyer and seller relationship in the context of Multi Component System Industries.

First, we uncover the factors that explain the choice of product performance contract specificity between the OEM and suppliers. We first set up an analytical model to explain the notion of an optimal contract specificity level and predict and further empirically test the role of different factors in the choice of contract specificity. We find that while the technology uncertainty decreases the level of optimal contract specificity, OEM's transaction specific investment, unconstrained mixing-and-matching of branded component, and extent of product monitoring technology increases the level of optimal contract specificity.

Second, we provide empirical evidence that any deviation from optimal contract specificity erodes value in the form of an increase in total transaction cost. In our transaction cost efficiency model, we also illustrate with a precise granularity that under-specified contracts lead to more ex-post dispute costs, and over-specified contracts lead to more ex-post contract monitoring cost and ex-ante contract writing cost.

Third, we investigate how contracts, investments in strategic capabilities such as monitoring technology, the overall firm strategy, and transaction costs determine the firm performance. We find that not every transaction cost is a dead weight loss in terms of product performance. Most notably we find that ex-post dispute costs are associated with higher product performance when there is a major incident such as component failure between the OEM and the supplier.

Methodologically, this dissertation proposes to use a combination of field work, mathematical modeling, conceptual theory building, and empirical analysis of primary data about firm practices.

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I would like to commend my supervisor, Prof. Sourav Ray, who selflessly and patiently helped me in many different ways become the person I am today. Without Sourav's directions, I could not succeed, let alone surpass this seemingly insurmountable topic at first. I also like to thank my other supervisory committee members, Prof. Devashish Pujari and Prof. Ruhai Wu, whose feedbacks in multiple occasions helped me to a great extent. Finally, I would like to express my gratitude to my alma mater, McMaster University, as an engaging institute and a charming community where I proudly call home.

Dedication

I dedicate this work to three generations of inspiring, loving, and wonderful individuals in my life, my mother Rajieh, love of my life Neda, and my little princess Arissa, whose presence, each in their unique ways, gave me the very much needed motivation and strength to excel in this research.

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List of All Abbreviations

AVE	Average Variance Extracted
CFI	Comparative Fit Index
CLF	Common Latent Factor
Coeff	Coefficient
COMIMP	Component Importance
COMRAT	Component to Product Price Ratio
Diff	Differentiation
FINFREQ	Financial Transaction Frequency
GVA	Governance Value Analysis
HET	Customer Heterogeneity
INTRES	OEM Integrative Resources
LC	Low Cost
LTSA	Long Term Service Agreement
MCS	Multi-Component Systems
MOD	Modularity
MT	Monitoring Technology
MXM	Mixing-and-Matching
NKEYCOM	Number of Key Components
NPOTSUP	Number of Potential Component Supplier
OEM	Original Equipment Manufacturer
OEMTSI	Original Equipment Manufacturer Transaction Specific Investments
PE_Out	Product Enhancement Outcomes
PPC	Product Performance Contract(ing)
PPCSpec	Product Performance Contract Specificity
PROIMP	Product Importance
SUPTEC	Proprietary Technology of the Supplier
SUPTSI	Supplier's Transaction Specific Investments
SE	Standard Error
TC	Transaction Cost
TCA	Transaction Cost Analysis
TCE	Transaction Cost Economics
TECUNC	Technology Uncertainty
TENURE	Tenure of Relationship
TRANFREQ	Transaction Frequency
TRANSCOPE	Scope of the contract
UNPINN	Unpredictability of Innovation

Chapter One Introduction

This thesis attempts to understand how Original Equipment Manufacturers (OEMs) and their suppliers in multi-component systems industries organize their transactions to ensure greater product performance. In the process, I investigate the impact of new component performance monitoring capabilities that are part of the emerging Internet of Things (IoT) technologies, in supply chain contracts. I also calibrate the potential efficiencies from saving transaction costs with more efficient contracting and estimate the impact on firm performance as an outcome of efficiency of contractual provisions, deployment of marketing resources and corporate strategic positioning.

Original Equipment Manufacturers (OEMs) procure components from several suppliers. Often, these components are part of a Multi-Component System (MCS). OEMs sell such MCS in the market as their final product. Such systems, or products, pervade both industrial and consumer markets. For example, heat exchanger systems comprise heating elements, valves, pumps, condensers, evaporators, filters, electronic controllers etc.; waste water treatment plants comprise of chemical agent dispensers, aeration tanks, pumps, actuators, sensors etc.; computers comprise of motherboards, fans, hard drives, memory, power source, audio and video cards etc.; electric bikes comprise of frames, gears, brakes, battery packs, motors etc. In each of these cases, the desired end product performance levels are often critically dependent on the performance of each individual component. As such, the OEM is not simply neutrally disposed to the performance of the constituent components of the MCS. In fact Product Performance Contract (PPC) clauses are often included in the procurement contracts between the OEM and its suppliers or negotiated within separate agreements like Long Term Service Agreements (LTSA). The industry concerns with such component performances are in keeping with broader procurement trends. Starting in the mid-90s, the US Department of Defense, which is the single largest buyer of industrial goods in the free market economies, made a concerted push to move from detail based specifications to more performance based specification in their procurement agreements.("Defense Standardization Program: Performance Specification Guide," 1995) This put all its own suppliers, many of whom are OEMs, on notice as well.

The aspiration of performance based contracting notwithstanding, negotiating product performance contracts is an inherently complex task in multi component systems that pervade the OEM industry. One of the key challenges is the nature of the technology itself. Multi component systems are characterized by interdependencies between their constituent components. In the event of a product failure, these interdependencies often make it difficult to establish the cause and the locus of responsibilities. At issue quite often, is ambiguity surrounding whether sub-par performance of a supplier component triggered the product failure. Consider for example, that a heat exchanger system is not generating enough steam pressure. There could be several scenarios driving this outcome. The pump may be malfunctioning or the heat exchanger element is failing resulting in sub-optimal steam production. Alternately, perhaps the filtration component is not working optimally, leading to a cascading sequence of failures across the system as sediments and minerals build up at unwarranted levels. In ascertaining and fixing the cause and locus of responsibilities, significant investigative efforts may be required and even that may result in ambiguous conclusions. In the absence of well-specified contracts between the OEM and its suppliers, opportunistic channel partners could shirk their responsibilities and avoid the resulting liabilities by contesting the findings, calling for renewed investigations and attempting to renegotiate existing agreements. These would impose costs not only on the OEM but in the event the direct costs of product failures are spread across all parties involved in the product, this could lead to even more disputes among the supply chain partners.

Such disputes between industrial channel partners are almost inevitable and will not come across as a surprise to either researchers or practitioner in the domain. The paradigmatic Transaction Cost Economics (TCE) perspective addresses these transaction costs as a key consideration for organizing firm to firm business relations (Dutta, Bergen, Heide, & John, 1995; Dutta & John, 1995; Heide & John, 1990; Rindfleisch et al., 2010; Stremersch, Weiss, Dellaert, & Frambach, 2003; Wilson, Weiss, & John, 1990). Largely deriving from TCE and related perspectives, the traditional marketing strategy literature has also built a rich tradition of studying these issues in business to business contexts (Houston & Johnson, 2000; Lusch & Brown, 1996; Mooi & Ghosh, 2010; Wuyts & Geyskens, 2005).

The extensive academic interest in these topics derives largely from the direct practitioner concerns in the area. Industry sources consistently comment on the high cost of such disputes. For example, a recent study conducted with British businesses estimates that the costs associated with dispute resolution between industrial buyers and sellers could amount to almost £33 Billion annually[1]. While much of these commentaries peg these costs to general partner disputes, our own field research in the HVAC[2] and Power Generating industries highlight the significance of these costs in the specific context of OEMs in MCS industries.

Several authors have considered the role of these costs on contractual specifications (Dahlquist & Griffith, 2014; Ghosh, Dutta, & Stremersch, 2006; Ghosh & John, 1999; Ruester & Neumann, 2009; Sande & Haugland, 2015; Wernerfelt, 2005). Intuitively, one would expect more comprehensive contracts, which are highly detailed and specified, would reduce potential disputes. This forecast would comport to the predictions of Transaction Cost Economics (TCE). Consequently, one would expect a higher level of product performance contract specificity would be observed when the potential for such disputes is high. However, writing detailed contracts is not costless for the manufacturer. First of all, writing such highly specified contracts is costly ex-ante. Second, such details do not completely obviate the need for the ex-post hazards of

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[1] "Cutting cost of disputes." Sheffield Telegraph. (October 22, 2009): 471 words.

[2] Heating Ventilation Air Conditioning

renegotiations and might even impose additional ones. This trade off between the ex-ante costs and the ex-post hazards were the specific subject of Mooi and Ghosh's (2010) paper.

The question I pose is how do these transaction costs operate when I take into account specific considerations of multi-component interdependencies. While the paradigmatic transaction cost considerations remain largely immutable and maintain their secular trends, the tradeoffs investigated in the earlier literature acquire far greater complexity and nuances, made more so by emerging capabilities within the OEM industries. In MCS contexts, while more comprehensive contracts incur greater ex-ante costs and reduce the likelihood of greater ex-post disputes, these also impose additional monitoring costs beyond just the hazards of renegotiating an expanded and more detailed set of clauses. For example, greater specificity of the contracts also imposes a greater burden on the parties, specifically the OEM, to ensure the different individual parties fulfill their end of the agreement. Without monitoring of contract compliance, not only do the legal grounds to enforce a contract diminish, but in the absence of hard data, dispute resolutions and renegotiations are not effective; thus rendering the highly specified contract less effective for the purpose. In other words, the contracting parties must manage the trade off between the ex-post costs of disputation and monitoring as well.

That said, there are new component monitoring capabilities that are fast becoming de jure in our industrial landscapes. These are part of the interconnectivity driving the

Internet of Things (IoT) technology and are fundamentally changing the way industrial channels operate by imposing not only new business models but also the way channel partners organize their business transactions. Take for example, the "Trended Condition Monitoring" capabilities sold by Rexroth of the Bosch group. They provide "real-time monitoring of key system parameters, (where)...The system parameters are selected based on their ability to indicate symptoms of an impending failure at an early stage. Early detection allows scheduled correction prior to an unexpected machine stoppage."[3] The applications range from preventive and predictive service arrangements to dispute resolutions in the event of a failure.

As OEMs face the trade-offs between the ex-post dispute and monitoring costs, the confluence of the transaction cost considerations and these new technologies, pose questions about the strategic impact of firm investments in such capabilities in the first place. In particular, given the likely strategic intent driving such investments in capabilities, it may not be enough to trace contract form to pure transaction efficiency considerations. In particular, not only does the specific impact of deviations from the "optimal design" on transaction efficiency become an important empirical question, but also do the implications of governance form and transaction costs with suppliers on the product performance. The emerging Governance Value Analysis (GVA) literature in

[3] https://www.boschrexroth.com/en/ca/service/preventive_and_predictive_services/condition_monitoring/trended_condition_monitoring (January 20, 1016)

marketing attempts to capture these trade-offs between governance form and strategic payoff (Ghosh & John, 2005; Sande & Haugland, 2015). While both TCE and GVA literature are primarily interested in firm performance, through transaction cost minimization and value enhancement, the dependent variable in some occasions is the product level performance (Anderson & Dekker, 2005; Mooi & Ghosh, 2010). That is because most of the manufacturer's performance is tied back to the performance of a key product. Firm performance is appropriately proxied with product performance because I am looking at MCS transactions or business transactions related to these product systems. The context is all related to product performance and product enhancements; therefore, product enhancement outcome, is the appropriate performance measure. Recall that this literature ignores the indirect role of governance form, i.e. through transaction costs, on the product performance. It could be because not until recently do we observe papers that try to estimate the transaction costs accurately (Duarte & Davies, 2003; Menon, Bharadwaj, & Howell, 1996), given the difficulty of measuring transaction costs. Without any intention to contrast the direct versus the indirect role of governance on product enhancement, I am interested in assessing the role of transaction costs on product performance. That is because transaction costs are inevitable outcome of any governance form from well designed to poorly designed ones. Moreover, a mere focus on transaction cost minimization, while ignoring the impact of such transaction costs on product performance, can compromise opportunities to enhance value for the OEM. On the other hand, marketing literature identifies the role of conflict as both functional and dysfunctional (Crocker & Reynolds, 1993; Wuyts & Geyskens, 2005). Similarly, I explore the functional and dysfunctional role of disputes in the industrial buyer and seller relationship in the context of the MCS. I regard dysfunctional disputes as the cost that does not add value (Matutes & Regibeau, 1992; Ray, Wood, & Messinger, 2012; Stremersch et al., 2003; Venkatesh & Mahajan, 2009), and hence consider it as deadweight losses. I also regard functional disputes as performance improvement mechanisms. This is to identify under what circumstances the transaction cost minimization paradigm is in line with or against OEM’s value enhancement effort. Ideally, when cost minimization efforts overlap with value enhancement effort the OEM is better off, as the cost savings are added to the value created. When these two events are against each other, the savings from transaction cost minimization is lost to value erosion. The impact of disputes on product performance cannot be identified intuitively, given the trade-off between the disputes and monitoring costs discussed earlier.

Empirically, I collect data from industrial buyers, OEMs, who are dealing with different key component suppliers. In the survey design, I ask for a supplier with whom the OEM has experienced a major component failure and another supplier with whom the OEM has experienced a minor component failure if any. This set up not only makes it possible to control for OEM specific effects, but also makes it possible to investigate whether disputes during a major component failure can act as functional disputes, and disputes during a minor component failure (if any) can act as dysfunctional ones. I find empirical support for both functional and dysfunctional explanations.

There are two streams of literature in marketing and economics that could presumably help us unpack the issues at stake here - the stream of research on multi-component systems and the other on warranties. The emerging literature on MCS, mostly elaborates on the impact of the multi-component interdependencies on marketing mix choices (Balachander, 2001; Chu & Chintagunta, 2009, 2011; Soberman, 2003). Unfortunately, this line of work is not developed at the level of granularity required to gain insights into how product performance contracts should be organized in MCS industries.

On the other hand, the warranty literature, while building up an impressive set of insights into the drivers of different types of warranty choices, largely gives the business to business industrial context, a pass, being largely focused on the business to consumer transactions (Ghosh et al., 2006; Ghosh & John, 2005, 2009; Grewal, Chakravarty, & Saini, 2010; Lilien et al., 2010; Mooi & Ghosh, 2010). This limits our ability to draw directly applicable insights.

There is however, a growing literature in marketing that explores interdependent components and supplier relations in business to business contexts such as manufacturing (Ferguson, Paulin, & Bergeron, 2005; Poppo & Zhou, 2014). There is little guidance here that would allow us to unpack the implications of such interdependencies in the context of MCS product performance contracting.[4]

To summarize, this research has four main objectives:

- First, to characterize the nature and scope of Product Performance Contract Specification (PPCSpec) between component suppliers and industrial manufacturers, especially contract characterizations, such as the product performance contract specificity.
- Second, to calibrate the associated ex-post disputation and monitoring costs and ex-ante contract writing cost. To the best of our knowledge, the compensatory nature of the ex-post costs has not been investigated in the literature yet. In this part, I seek to understand how deviations from optimal contracts impact the realized transaction costs.
- Third, to characterize the role of component monitoring capabilities on contract choice.
- Finally, to identify the conditions that impact product performance at the confluence of contractual relations, deployed strategic capabilities, the firm's strategic intent, and transaction costs.

[4] To the best of our knowledge, Mooi and Ghosh (2010) is the only related paper.

In Chapter Two, I will review four main literatures germane to this research. The theoretical inspiration has been drawn from the contracting literature related to Transactions Cost Economics (TCE), Governance Value Analysis (GVA), the traditional warranty literature, marketing strategy, and the agency theory. I will look at MCS literature and further elaborate on compatibility, bundling and mixing-Matching literature in this domain. Then, I will explain the literature in TCE, for it sheds light on the concept of the transaction costs. To show the link between the governance choices and performance, I will elaborate on the GVA literature. Then, I will review the extant literature on PPC, and the way performance contracts are crafted. Finally, I will elaborate the warranty literature as one of the classic means of promising performance.

In Chapter Three, I provide the anecdotal evidence collected from the field. It will cover three main areas: The transaction costs, product performance contract specificity, and performance implications of the governance choices. Although, TCE provides the theoretical basis for transaction costs, there are still areas to be explored. Specifically, I pay attention to the trade off between monitoring and dispute costs. Both of these costs happen ex-post to the transaction. These ex-post costs are also significant costs. Managers often spend numerous efforts to minimize total transaction cost, by choosing the correct form of governance mechanism.

In Chapter Four, I start by elaborating on the conceptual basis of the main constructs, i.e. product performance contract specificity, and transaction costs. Then, I will propose an analytical model in the most general form. One of the outcomes of this model is the main propositions about the relationship between the ex-post transaction costs, and product performance contract specificity. Then, relying on prior literature and theory, I develop some testable hypotheses in the domain of characterizing the contracts, and the role of deviation from optimal form of contract on transaction costs. The application of the analytical model is limited to this section.

Next, I conceptualize some more testable hypotheses on the relationship of ex-post transaction costs and product performance, in the form of OEM's end product enhancement outcomes, controlling for the effect of governance, business strategy, and product monitoring technology. The theoretical basis of the control variables has been borrowed from GVA paradigm.

In Chapter Five, I elaborate on the data that I have collected from OEMs in different industries. I also explain how two different types of suppliers are surveyed from the OEMs. I give details about the method, and the survey, as well as sample characteristics. I also talk about the measurement reliability and validity.

In Chapter Six, I estimate the product performance contract specificity. I find support for my hypotheses that OEM's transaction specific investments, technology uncertainty and monitoring technology are determinants of the product performance contract specificity.

In Chapter Seven, I estimate each of the three transaction costs, i.e. ex-ante contract writing, ex-post monitoring, and ex-post disputation costs. I estimate these three equations simultaneously to account for the correlation of the error terms in these three equations. . All of the predictions of chapter four find empirical support. I can show that the positive deviations from product performance contract specificity, in the form of contract over-specificity, is correlated with an increase in contract writing and monitoring costs, while it is correlated with a decrease in disputation costs. I can therefore, show that the compensatory nature of transaction costs can even be found in the ex-post transaction costs. To the best of my knowledge, no other study has uncovered the compensatory nature of the ex-post transaction costs in the field.

In Chapter Eight, I present results of the product performance estimations. There is a growing literature on the governance and performance link. Performance is measured using different variables: exchange performance (Cannon et al., 2000), exchange relationship (Mooi & Gilliland, 2013; Poppo & Zenger, 2002; Susarla, Barua, & Whinston, 2009), exchange satisfaction (Jap & Ganesan, 2000; Poppo & Zenger, 2002), relationship satisfaction (Mesquita & Brush, 2008), production efficiency (Hoetker & Mellewigt, 2009), alliance performance (Ghosh & John, 2005; Sande & Haugland, 2015), and product enhancement and cost reduction (Mooi & Gilliland, 2013; Sande & Haugland, 2015). There is also a small literature around the impact of deviations from optimal contracting on performance (Mooi & Gilliland, 2013; Sande & Haugland, 2015). In this chapter, I show that ex-post transaction costs with suppliers in the up-stream impact OEM's product enhancement outputs both positively and negatively. More specifically, ex-post transaction costs when the OEM is not involved in any major component failure continue to act as dead weight losses. That is because they are negatively correlated with product enhancement outputs of the OEM. More interestingly, I find that when the OEM is engaged in a major component failure with a key component supplier, such ex-post disputes are positively correlated with product enhancement outputs. Furthermore, I find evidence that marketing strategy and product monitoring technology can moderate the relationship between product performance contract specificity with suppliers on product enhancement outputs. To the best of my knowledge, no other study has achieved this before.

Chapter Two Literature Review

To shed light on performance implications of the multicomponent systems, I will first look at relevant streams of literature. In the beginning, I will review the growing literature of multicomponent systems. Then, I will elaborate on transaction cost economies literature, as it explores the efficiency of chosen governance modes when exchanging the components from the component supplier to system manufacturer. Next, I will address the governance value analysis literature to examine the performance consequences of the governance mechanism between the manufacturer and supplier, on manufacturer's performance in the presence of unique market strategy and resources. Finally, to review the performance aspects of a multicomponent system manufacturer I look at the product performance contract and warranty literature. In the end, I summarize the gaps that I have identified in the literature.

Multicomponent Systems

Given their prevalence in both industrial and consumer markets, multicomponent systems (MCS) are of great interest to marketers. Multicomponent systems are those products that have multiple interacting components (Ray, Wood, & Messinger 2012). Matutes & Regibeau (1989) have also defined multicomponent systems as a set of components that are not intended to be used separately, but still can be bought individually. Perhaps, Matutes & Regibeau (1988) is one of the early studies that treated the systems as a combination of components and explored the implications for business strategy and policy. Nevertheless, how characteristics of MCS impact marketing strategy is still an emergent area of research (Ray et al., 2012).

In the MCS literature, there are themes that roughly map into two main domains: technology and marketing strategy. The technology domain that borrows from industrial organization literature focuses on standardization and compatibility. In this literature, the processes that illustrate how standardization and compatibility happen, and the marketing consequences of such manufacturing level decisions are important. The second domain, marketing strategy, looks at another set of manufacturing level decisions such as bundling, and also marketing level decisions such as mixing and matching. Albeit, bundling literature is bigger than MCS literature, as bundling non-interacting components, for example, movie ticket and popcorns, does not have any relevance in MCS domain. Each of these bundling or mix-and-matching decisions has noticeable marketing consequences, and, as a result, are of interest to marketers.

Compatibility - Most of the classic MCS literature is around compatibility of the components (Matutes & Regibeau, 1989). Compatibility can be achieved at the design and production stage. It can be also achieved ex-post in the market by the application of converters. A converter refers to a device that makes interaction of two parts possible, specifically when these two parts are manufactured under two different standards which makes their interaction impossible. Same as any other manufacturer, multicomponent system manufacturers are faced with a decision to manufacture either standard products or differentiated products. Farrell & Saloner, (1986b) have shown that there is a trade-off between the standardization and variety. Variety leads to differentiation. Differentiation is valued in the market because the buyers are heterogeneous. Differentiated products may serve different needs of different buyers better. One the other hand, standardization has some benefits. It can help reduce the cost, because of the economies of scale, and it can lead to higher utility in case there is network externality in place. In their model, Farrell & Saloner, (1986b) have shown that there could be multiple feasible situation in the market. They show, it is possible to have an equilibrium that involves too much or too little standardization. A main take away from their study is that a market equilibrium that involves standardization may have happened because of historic reason. Therefore, standardization may not be the most efficient form in that case.

Boatwright & Nunes, (2001) have also shown the trade-off between standardization and variety affects sales in the retail industry. In their natural experiment, they found that the focal retailer experienced an 11% growth in sales when 94% of the categories experienced considerable cuts in their SKUs. Their study mainly includes low-involvement goods that differ very little at the attribute level, in the context of grocery retail.

Farrell & Saloner, (1986a) have studied compatibility. This paper illustrates the trade-offs of the standardization and differentiation at the market level. They have pointed out three main benefits of compatibility: a) interchangeability of the complementary products, b) network externality, and c) cost savings because of economies of scale. All these benefit encourage standardizations. The authors have argued that standardization increases industry demand, as a result of the network externality. They have also studied a case that compatibility can inhibit innovation. That is if there is an installed base for a system and when the transition to the new technology happens to be gradual, the early adopters incur high costs of incompatibility during the transition period. This cost creates an excess inertia in the install base. On the other hand, if the new technology is adopted, there is excess momentum which facilitates further adoption and inhibits adoption of other new technologies.

In the business strategy domain, Matutes & Regibeau, (1989) have studied the strategy implications of manufacturing a standard component that can be incorporated into different systems. They have been able to show since the manufacturer of such system needs to commit to a same price across different submarkets; it is an optimal strategy to limit the scope of entry.

In another paper, Farrell & Saloner, (1992) have studied the role of converters to create compatibility. They have shown that compatibility is also achievable ex-post at a cost through converters. When an incumbent dominant firm in the market supplies one technology, the firm has an incentive to obstruct other firms' efforts to gain compatibility with its product. The firm can achieve this goal by making the design of converters expensive. If the compatibility is achieved by the use of the converter, but the product performance is not at its ideal level, the dominant firm may sustain its dominance. It is true when the product is still attractive from the performance point of view and when the rival firm's technology is expensive because it is not costless to make a converter.

Bundling - MCS can also be viewed at from bundling perspective. In an effort to consolidate marketing definitions in the domain of bundling, Stremersch & Tellis, (2002) have defined the term bundling as follows: " Bundling is a sale of two or more separate products in one package". They have elaborated that the term separate is a key term here. They have noted that there should be a market for each product individually. Authors give examples of obvious examples of bundles such as various events tickets bundled together, to a less obvious example of bundles such as personal computers. Ray et al., (2012) and Venkatesh & Mahajan, (2009) identify the distinctive feature of MCS from bundling in the interaction of bundled elements with each other as in the personal computers example, which is not necessarily a concern for simply bundled products as in the event tickets example.

One stream of bundling literature looks at the pricing strategies regarding the bundled choices. (Matutes & Regibeau, 1992) for example, show bundle sellers can benefit from charging premium prices when there is heterogeneity between customers' reservation price and the bundle price.

Nonetheless, many of the prior literature in marketing on bundling are still relevant for MCS. One notable paper that has studied bundling decisions and compatibility is (Matutes & Regibeau, 1992). In a model, they have shown that for a wide range of parameters, firms choose to manufacture compatible products. Moreover, firms tend to give discounts to customers who buy different components of the system from the same seller. Authors have been able to show if firms avoid such discounts, they would be better off. (Venkatesh & Mahajan, 2009) have also looked at the motivations behind unbundling of the industrial systems, or multicomponent systems. They have shown that when the customers are heterogeneous and when there are different competing firms that can offer compatible components, the market can grow if the new systems are modular or include a superior component. The new systems are the ones that are created by mixing and matching different component brands. In this context, if the supplier unbundles the multicomponent system, it is the buyer that performs mixing and matching of the components. Overall, mixed bundling is not necessarily superior to pure bundling or pure component strategies (Venkatesh & Mahajan, 2009). Based on their analytical model, Venkatesh & Kamakura (2003) propose that a seller may be better off pursuing pure strategies, i.e. pure bundling or pure component, depending on a number of factors. These factors are the marginal cost of production of each component, the level of the competition, correlation in reservation prices of the components, and the degree to which components are substitutable or complementary.

More recently, there is a notable study on that looks at the bundling of the products and services. Roy, Ray, & Ghosh (2015) have looked at the bundling of the products with technical consulting services, TCS. They argue that the bundling choice at the contract level is influenced by economizing on the cost of securing information which is vital for the buying firm to create value from supplier's equipment.

Stremersch, Weiss, Dellaert, & Frambach, (2003) have looked at the industrial buyers motivations to outsource the system integration to suppliers or multiple sourcing of the components in technology intensive markets. Authors have shown that the buyer's technological know-how level is a key factor when deciding about outsourcing of the system integration or multiple sourcing. That is because different industrial buyers have varying degrees of concern about their tacit knowledge leakage to their suppliers. Building their theoretical framework on transaction cost analysis and production cost theory, they have offered some key insights on when a buyer may engage in in-house system integration and multiple sourcing, in the context of telecommunication industry. They have found that industrial buyers with medium levels of system know-how prefer outsourcing, and multiple sourcing. On the other hand, industrial buyers with low or high level of know-how prefer in-house system integration and single sourcing.

Mixing and matching – In industries where the customers can mix and match their own systems, the supplying firms are faced with the decision to manufacture compatible systems with those of rivals (Ray et al., 2012). One can refer to the buyer level mixing and matching as ex-post bundling. However, system design and architecture should allow consumers to do so. Multicomponent systems can be loosely or tightly coupled (Ray et al., 2012). In loosely coupled systems customers usually have some degree of flexibility of choosing different components based on their preferences. Customers may choose components from different supplier brands. In their model, Matutes & Regibeau, (1988) showed that compatibility of the components from different suppliers results in higher customer choices. Also, they have shown that in the absence of network externality manufacturers still have incentives to manufacture compatible products. The reason is first, compatibility enables customers to build their own ideal system, and second, compatibility weakens the competitors' incentives to cut the prices. Any price cut leads to higher sales for other manufacturer's as well. However, this insight does not suggest that compatibility, and thus loosely coupled systems are the only viable solution. Many anecdotal pieces of evidence support the existence of both loosely and tightly coupled systems in both business to consumer and business to business markets. For example, in the personal computer industry, Apple products are less compatible with the components of other manufacturers. In fact, the insights derived from (Ray et al., 2012) model suggests that compatibility, and thus loosely coupled systems, is a symmetric perfect Nash equilibrium if standardization is costless. Otherwise both pure strategies, i.e. compatibility and incompatibility exist as two separate equilibria.

In contrast to loosely coupled systems, tightly coupled systems offer less flexibility of mixing and matching to the customer. In such systems, in the extreme case, customers can only choose a set up which is designed by manufacturer (Ghosh et al., 2006). Manufacturers often price the components individually, in addition to the product, the system, in the lightly coupled systems. On the other hand, the manufacturer may not individually price and market the components in the case of tightly coupled systems.

The other example in the scant literature of the MCS is (Ray et al., 2012). Unlike (Ghosh et al., 2006) who explore MCSs in the business to consumer markets, (Ghosh et al., 2006) study such systems in the business to business markets. They have explored how modularity, technological uncertainty, customers' knowledge and vendor's customer knowledge mobilization resources can define the extent to which a vendor, i.e. a manufacturer, practices control over the customization of the system. The manufacturer can provide a highly customized system where customers have less opportunity to modify the system, i.e. tightly coupled system. Or the manufacturer can provide the compatibility standards, enabling customers to have more mixing and matching of components to achieve their desired design. The (Ghosh et al., 2006; Ray et al., 2012) paper's focus is on the relationships between an industrial manufacturer as the vendor, and an industrial buyer that uses the system.

Overall, the MCS literature offers insights about compatibility, bundling and mixing and matching. The literature is still in its nascent stage of uncovering the complexities inherent in MCS because of component interactions. There is a lack of many papers on managing the inter-component complexities. Particularly, when the components are from different suppliers, with a notable exception of (Williamson, 1996). This is a gap in the literature.

The current study aims to bridge the gap in the literature, by exploring the transactions related to manufacturing an MCS, between an OEM (or a manufacturer) and its multiple suppliers. In our setting, the manufacturer sells the assembled multicomponent system to the next member in the channel, so the manufacturer is not the user of the multicomponent system.

Next, I will review the transaction cost economics, TCE. This paradigm looks at the costs of transaction between an industrial buyer and seller. It is important because much of the creation of MCS happens in the context of inter-organizational exchange.

Transaction Cost Economics

This paradigm has become a mainstream theory in analyzing inter-organizational relationships and channel structures. In channels TCS is applicable to both the upper stream of the channels, i.e. supply chain, and to downstream of the channels, i.e. the distribution channels. In supply chain domain I seek to understand the industrial buyer and seller relationships. In distribution channel the relationship between the manufacturer and retailers is a typical area of study. TCE approaches the interaction between the firms from the lens of ex-ante and ex-post transaction costs. If transactions were costless, parties to an exchange would engage in value maximizing exchanges. This would occur apart from their power differences or even resource endowments (Williamson, 1985). In real world such transaction costs are far from being null, as a result parties to an exchange will organize to minimize these costs. Minimizing such costs will ensure joint value maximization.

A key characteristic of MCS is the functional interdependency of components. The component interdependencies make administering transactions involving MCS, complex for both the OEM and the suppliers. Thus, TCE presents a useful framework to investigate such bilateral arrangements (Williamson, 1985).

In industrial contexts, OEMs need to put some efforts to assemble these components. Also, OEMs have to either make or buy these components. TCE highlights the key independent variables, i.e. uncertainty, frequency, and asset specificity, which are antecedents of the governance forms. Different forms of governance are hierarchy, hybrid or market structure (Williamson, 1985). Some examples of each governance form in the context of MCS are as follows: Automobiles are a good example of MCS. The automotive OEM may have different structures in its supply chain. The OEM may buy the metallic body parts from an individual company. The OEM may also choose to acquire the supplier to exert closer control over body parts which are very critical for the final products fit and finish. It is an example of the hierarchy structure. The automotive OEM may engage in buying in tenders for more standard components such as nuts and bolts. It is an example of market structure. The hybrid structure is a combination of hierarchy and market structures. TCE predicts that when a firm invests in specific assets or when uncertainty is high, the firm chooses to safeguard its investments by choosing necessary safeguards. TCE posits that within governance structures the hierarchy structure offers the highest safeguards and the market structure the least (Williamson, 1985).

Empirical evidence on the efficiency of each governance form - Marketing has a long history of research in efficiency of governance forms. The notable examples are : (Cannon et al., 2000; Cannon & Homburg, 2001; Heide, 2003; Houston & Johnson, 2000; Poppo & Zenger, 2002; K. H. Wathne & Heide, 2004). Now, I examine these papers for their main findings.

Cannon et al. (2000) study the performance implications of two different governance structures, i.e. market and hybrid structures. Authors approach the hybrid structures from the relationship perspective, and have focused on relational social norms. Studying a sample of buyer- seller relationships, they show under what circumstances each structure is efficient. Form their empirical data, they find that increasing relational aspects of a governance structure involving contractual agreements increases efficiency when the uncertainty is high and not when the uncertainty is low.

Houston & Johnson (2000) look at the efficiency of contract-governed versus joint venture governed relationships. Authors demonstrate that joint venture is a preferred governance choice when 1) the level of seller's investment in the relationship is high, 2) the level of seller's performance ambiguity is high for the buyer, and 3) the brand reputation of the seller is poor.

Cannon & Homburg (2001) study the effect of the seller behavior on the buyer's product, acquisition, and operation costs, and the effect of these costs on the buyer-seller relationship in industrial settings. In their model, they propose and empirically test that such costs will mediate the relationship behavior and the buyer's intentions to expand its business with the seller. They find support for their hypotheses that buyers tend to increase purchases from the sellers that offer value to the buyer by lowering each of these costs.

In their empirical paper using a sample of information service exchanges Poppo & Zenger (2002) show whether formal contracts and relational governance can function as complements or substitutes. The authors suggest an alternative perspective that formal contracts and relational governance can function as complements. They find empirical support for their hypothesis. Companies that need to write highly customized contracts with their partners, still need to invest in their relational governance. They argue that formal contracts are good devices to set boundaries and contingencies, but when it comes to resolving conflict relational governance works more efficiently.

(Bradach & Eccles, 1989) draws upon the agency theory and examines the industrial purchasing practices, specifically the plural governance form. When a firm chooses to combine different governance forms such as market and hierarchy, the strategy is described as plural form approach (Bradach & Eccles, 1989). Heide (2003) argues that this strategy can be explained by using a perspective of solving information asymmetry problems, in the context of the buyer and supplier relationship. The party with less information has the incentive to opt an internalized form of exchange as a method of governance. In this paper, Heide (2003) has operationalized information asymmetry as a consequence of uncertainty.

(Anderson & Dekker, 2005; Mooi & Ghosh, 2010; Wuyts & Geyskens, 2005) study how the choice of governance form in the upstream influences the efficiency of the chosen governance form in the downstream. Examining the downstream and upstream governance forms in the apparel industry, the authors find support for their hypothesis.

They argue that the firm's ability to manage uncertainty in one relationship, i.e. with the buyers, is in part influenced by the firm's choice of governance in another relationship, i.e. with the suppliers, in the firm's network of relationships. Two specific issues are important in the relationship with the supplier, 1) supplier qualification schemes, and 2) the supplier incentive schemes based on the hostages. The transaction specific investments are an example of the hostage. The investment of one party into transaction specific items, that considerably worth less outside that relationship, can be used by the other party as a hostage. This study is particularly important as it explores the effect of one governance form on another across different dyadic relationships of a focal firm.

Moreover, a growing literature considers the efficiency implications of ex-ante and ex-post nature of the transaction costs (Anderson & Dekker, 2005; Mooi & Ghosh, 2010; Wuyts & Geyskens, 2005). They explore the effect of contract choice on transaction costs. In their view, inefficient contracting can affect transaction costs and firm performance.

In an empirical paper on transactions of information technology products, Anderson & Dekker, (2005) explore the mechanism that the buyer can use to mitigate the supplier's opportunism. Authors examine whether there is a relationship between transaction and supplier characteristics with the control structure. Then, they examine whether misalignment between transaction and supplier characteristics and the control structure causes any ex-post performance issue. They find support for their hypothesis that the cost of contracting is associated with the increase in the usage of contractual terms on after sales services, assignment of the rights, and the legal recourse. They also show evidence that better-aligned governance mechanisms with transaction hazards mitigate the risk of ex-post performance issue, however, the cost of such complete contracts are nontrivial.

Another empirical study that looks at buyer-seller relationships is Wuyts & Geyskens (2005). Authors examine how organizational factors such as culture affect the choice of governance form when a buying firm tries to manage its relationship with a supplier. They investigate the efficiency of contractual versus relational based governance forms. They find supporting evidence that contracts are efficient when the buyer and seller are not close or when the buyer and seller are too close. The latter may happen when the focal relationship is a subset of a network of close mutual contracts. The relational governance form works better when the buyer and seller are moderately close to each other.

More recently, Mooi & Ghosh (2010) have regarded the contract specificity as a key contract characteristic. They have investigated the antecedents to the contract specificity, and the effect of contract specificity on ex-ante contract writing and ex-post monitoring costs. The authors have empirically tested their hypotheses in a context of companies that procure information technology products. They have been able to show that deviation from desired level of contract specificity has some transactional cost outcomes.

In another recent paper, (Ghosh & John, 1999) explore the effect of ex-ante contract terms on ex-post monitoring and enforcement efforts, in a context of franchisor-franchisee relationship. The authors posit and find empirical support for that an increase in the level of the contract terms, or contract completeness, reduces the level of monitoring and enforcement, as these ex-post efforts become redundant. They also find that high levels of contract one-sidedness, i.e. the degree to which contract favor the franchisor, is correlated with increase monitoring but decreased enforcement.

One major ex-post transaction cost in any transaction involving an MCS is the cost of renegotiations between the buyer and the seller, when a product fails, because of a component failure, or the product falls short of meeting an agreed level of performance, because of a performance failure in a component. This idea is prevalent in both business to consumer (B2C) and business to business (B2B) markets. The applications of the warranty contracts are known as a tool to regulate such ex-post renegotiations in B2C markets. In the next section, I will review warranties in more depth.

However, in the B2B markets the only tool to address the actions and requirements when there is a component performance shortcoming is still a contract. Often, these contracts are the procurement contracts in the first place, with added terms and conditions to cover contingencies surrounding a component performance failure. There is evidently a gap in the literature, in the understanding of how variation of such terms and conditions, i.e. contract specificity, affect the transaction costs, specifically ex-post ones. Moreover, it is not evident in the literature how a change in contract specificity can influence the product and firm performance. To understand the influencing factors of the performance, in the next section, I will review Governance Value Analysis paradigm that explores the relationship between transaction costs and performance.

Governance Value Analysis

Another framework in marketing literature, i.e. governance value analysis (GVA), extends TCE to address marketing strategic decisions (Ghosh & John, 1999). Critics of TCE have highlighted that TCE's mere focus on transaction cost minimization fails to explain difference in strategies among the firms in a market which are exposed to the same exogenous variables identified by TCE (Zajac & Olsen, 1993). TCE has also been criticized for its little insight to strategic choices that companies make in order to improve and claim value (Ghosh & John, 1999).

One can summarize the main contribution of TCE to inter-organizational relations as the ability of predicting the optimal governance form, given the transaction attributes. A main assumption here is that the transaction attributes are exogenous. The firms which choose the proper type of the governance will incur less governance cost in the exchange process.

Moreover, GVA framework suggests that the choice of governance form in the firms' relationship can be explained by transaction attributes, firms' position in the market, and the resources at hand. This framework also suggests that these four variables, i.e. the form of governance, positioning, attributes and the form of governance are endogenous. Therefore, the changes in one can affect the other variables as well. Collectively, these four variables can affect firm's performance. A focal firm's decisions over each of these four variables can constitute the firm's strategy, as GVA claims ultimately the firm's performance is affected once there is a change in one of these variables (Ghosh & John, 1999).

In sum, GVA adds to our insight why firms act differently specifically when it comes to claiming a jointly created value with a partner.

The GVA model adds to the existing approach of TCE to the governance design, in three different areas.

First, GVA highlights the idea of joint value maximization between the firms engaging in a transaction, as an important motive. GVA emphasizes that firms rarely create value in isolation. More explicitly, GVA highlights two essential elements of joint value maximization goal, i.e. value creation and value claiming. GVA attempts to explain how different governance forms differ in their value creation and value claiming aspects. Moreover, GVA highlights that these aspects are in fact affected by firm's position in the market and the way the firm can leverage its resources, in addition to transaction attributes. The differences of different governance structures which are defined by TCE are contrasted based on the value creation and claiming in the following.

Parties to an exchange can jointly create value, yet one party claim the value opportunistically. TCE advises three different governance mechanisms which are different in their value creation and value claiming aspects (Nickerson, Hamilton, &

Wada, 2001), i.e. market, hierarchy, and hybrid. In the market mechanism, parties enjoy higher autonomy and act more independently. They can sever ties and form other ties with other parties who offer higher value, in the quest higher value. The value claiming phase is also safeguarded by threat of cutting all future transactions. In contractual transactions, contracts provide legal safeguards against future opportunistic activities. In the hierarchy mechanism, the incentives to create value are much lower compared to that of market mechanism. However, the value claiming phase is far less at risk, as most of the transactions are done either internally or within vertically integrated businesses. The hybrid mechanism combines the elements of the other two mechanisms. Parties engage in relational governance where both parties have transaction specific investments and they are trying to govern the relationship using both social norms and legal tools such as contracts. Based on TCE framework, one expects the relational mechanisms be more effective than the market mechanism in their value claiming power and be inferior to the hierarchical ones. Also, one may forecasts that the relational mechanism be more effective in offering higher incentives for value creation than the hierarchical mechanism and be inferior to the market mechanism.

Second, GVA fashions firm strategy as a key element of governance design, by including the positioning and resource endowments of the parties to a transaction into the picture. As a result, in order to remain competitive, a market position change should be accompanied by realignment of the governance forms, and the resource profile of the firm.

Third, the GVA framework offers insights on how to test comprehensive models, including both value creation and value claiming motives. TCA treats the value creating attributes of the transaction as given in the prediction of the governance form. An example of such attributes is the transaction specific investments that parties carry out to create value jointly. By treating the value creating aspects of the transaction as exogenous or given in TCA framework, most of the governance models are regarded as cost minimization tools. GVA suggests however, that in order to test both value-creating and value-claiming elements, one should regard both transaction attributes and governance forms both endogenous.

GVA framework has been empirically tested in different contexts. I will now examine those domains. A summary of all papers, in GVA domain are also presented in Table 2-1. These papers explore the main GVA constructs, i.e. resources, positioning, governance, and exchange attributes, in their empirical studies.

Table 2-1. Empirical Papers on GVA that Explore the Inter-correlation between GVA Constructs

Domain of the Study	Paper	Resources	Positioning	Governance	Attributes
International Distribution	(Ruester & Neumann, 2009)	✓	✓	✓	✓
Organization of Production	(Ghosh & John, 2005)		✓	✓	✓
OEM-Supplier Relationship	(Wernerfelt, 2005)	✓	✓	✓	✓
The Scope of the Firm	(Wernerfelt, 2005)	✓		✓	
Supply Chain Link	(Ghosh et al., 2006)		✓	✓	
Product Customization in Industrial Markets	(Ghosh & John, 2009)	✓		✓	
Branded Components	(Dutta & John, 1995)	✓		✓	✓
Dual Sourcing	(Dutta & John, 1995)	✓		✓	
Managing Retail Relationships	(Gooner, Morgan, & Perreault, 2011) (Dahlquist & Griffith, 2014)	✓		✓	✓
Multidyadic Industrial Channels	(Porter, 1985)	✓		✓	✓

International Distribution - Nickerson et al. (2001) have studied the market of different international courier and small package service companies in Japan. They have been able to show that the organization's resource profile supports the competitive strategy, i.e. the market the organization positions itself. Moreover, they have found evidence that this resource profile should be supported by proper governance structure so that the firm can create product and service attributes that are suitable for the chosen target market position. More specifically, they have studied companies that are primarily positioned as 'document specialist, 'full-line services', and 'package specialists'. In this market, firms are differentiated based on their speed and reliability of the delivery service. Document specialists are considered high-end in this market, whereas the package specialists are considered low-end. The full-line service companies have positioned themselves between the other two. Using a 3SLS model, Nickerson et al. (2001) have been able to show that the level of specific investments in the IT infrastructure of each company varies and can be explained by the market position. They have been able to show that firms which have positioned themselves in the high-end market, i.e. document specialists, make more idiosyncratic investments in IT infrastructure than full line service companies and package specialists. These high-end companies are also more vertically integrated with transportation services, i.e. the governance and positioning link. Finally, these high-end firms deliver faster service, i.e. the link to the firm performance.

Organization of Production - Ruester and Neumann (2009) have studied the liquefied natural gas (LNG) industry. This study sheds light on the strategy-investment and strategy governance links. Using Porter's strategic positioning framework (Ghosh & John, 2005), they have identified three different positions in this market: chain flexibility, nationalized companies, and flexibility strategy. They argue that each of these market positions should be supported by different degrees of investment. For example, firms that choose chain optimizer strategy need to make more investments than those which choose flexibility strategy. Moreover, the latter companies need to make more investments than nationalized companies. They have also been able to show that the likelihood of vertical integration is highest amongst firms that chose chain optimizer strategy followed by companies that choose flexibility strategy and then followed by nationalized companies.

OEM-Supplier Relationship - Another study that looks at the inter-relation of GVA framework components is (Wernerfelt, 1997). They have examined the effect of the fit between OEM's specific investment (in the relationship with the suppliers) and the choice of governance on the firm level outcomes (cost reduction vs. quality enhancement), when the OEM's market resources vary. Using primary contract-level data from OEMs they have shown that more complete contracts lead to better cost reduction outcomes, whereas less complete contracts lead to better product enhancement goals.

They also show that firms with better market resources, e.g. high market share, tend to claim value by using more complete contracts with their suppliers. However, when it comes to product enhancement goals, such OEMs have to choose less complete contracts to foster innovation and product enhancement with their suppliers. At the same time, less complete contracts also give suppliers a better position to claim and take away a part of the jointly created value.

The Scope of the Firm - Wernerfelt (2005) combines resource-based view (RBV) of the firm and his adjustment cost theory (Wernerfelt, 1997) and shows how product development resources of the firm can affect both vertical and horizontal scope of the firm. The vertical scope of the firm is the extent to which the firm engages in make versus buy decisions. The horizontal scope of the firm is the breadth of the product lines that the firm is producing. In this study, he argues that firms with higher levels of product development resources tend to do frequent adjustments in their relationship with their suppliers. These adjustments are not costless. Moreover, since such resources are tacit that makes it hard to present them in a contract. As a result, such firms end up increasing the vertical scope by internalizing the suppliers, and expanding the vertical scope by entering into new product markets.

Supply-Chain Link – Wathne & Heide (2004) have examined the effects of supply chain practices on firm's strategy in downstream relationships with customers. Remember that Gosh and John (2005) studied similar relationship but in reverse order, i.e. the role of strategies in downstream on upstream supply chain strategies. Wathne and Heide (2004) show that in apparel industry firms can be flexible in their customer relationships, if a) they have done extensive supplier qualification effort, and b) there is symmetry in the suppliers' and the focal firm's hostages. One can observe that this study examines the governance-positioning link of the GVA framework.

Product Customization in Industrial Markets – Ghosh et al. (2006) have looked at the product customization of the complex product and addressed whether the buyer or the seller should take control in this context. The authors have used a model which combines RBV and TCA. They find that firms with the higher ability to incorporate customer information into their customized products have a better position with respect to the lower coordination costs and vice versa. More knowledgeable industrial buyers are more likely to carry out product customizations. However, vendors' knowledge mobilization resources, i.e. the ability to understand and act upon customer information, can moderate this relationship. Such vendors can provide customized products in the first place and control the industrial buyer's need to carry out customization.

Branded Components – Under the component branding practice, the OEM signs a contract with the supplier to use explicitly supplier's brand in its marketing efforts to market the product. This marketing practice between the OEM and the supplier(s) is a good context to examine the effect of resources, e.g. supplier's brand, and the governance choices between the industrial seller and buyer. Gosh and John (2009) propose that branded components are used for leveraging supplier's brand, and safeguarding the supplier's specific investments that are needed for customization. Using contract-level data from three industries from the OEM side, they have been able to show empirical evidence for both safeguarding and leveraging. They have been able to show that the safeguarding argument even holds for suppliers with moderate levels of brand reputation. They have suggested that the OEMs can benefit from branded component contracts by leveraging resource profile of their supplier and by safeguarding the supplier's investments that are needed for creating customized components that lead to customized final products. Such safeguarding will limit supplier's opportunism.

Dual Sourcing: Securing Customer Commitments – Dutta and John (1995) have examined the dual sourcing phenomenon by building a game theory model and running experiments. They have been able to show that firms with proprietary technology can grow their market by reducing customer side lock-in risks. One way to achieve this goal is by licensing the proprietary technology to competitors at a nominal fee. One prominent example of this practice in the marketplace is IBM, where IBM licensed its architecture to other companies free of charge so that they could create clones. They have shown that a licensor with low ability to differentiate its product from the invited competition ex-post will help its customers to enjoy the product at competitive prices. However, a prudent licensor with the ability to differentiate its product ex-post can enjoy the growth of the market as a result of licensing and reap the benefit of its differentiation from other compatible products of the licensees.

Managing Retail Relationships – GVA framework has even been tested empirically in the retail settings. There are two notable studies. First, Kim et al. (2011) have studied the partially integrated channels in the fashion industry in South Korea. The partially integrated channel refers to the practice of working brand manufacturers employees in the retail premises jointly with retailers' sales people, on a full time basis. They have shown that brand manufacturers resource profile and transactional attributes such as performance ambiguity of the sales force, and market uncertainty affect the degree a brand manufacturer seeks to exert control or show flexibility in its relationship with the retailer. They found out that brand manufacturers with higher resource profile are likely to increase their control and remain flexible with their retailers as market uncertainty and sales force performance ambiguity tend to increase.

Gooner et al. (2011) is another notable study in this domain. They have examined the category management in the grocery retail environment. They have shown that the marketing capabilities of the retailer and the unique set of resources that the retailer poses and brings to the relationship with a lead manufacturer affects two aspect of category management, i.e. the intensity of the category management effort, the influence sought by the lead manufacturer, and the degree to which manufacturer may act opportunistically.

Multidyadic Industrial Channels – Dahlquist & Griffith (2014) have studied the governance in a vertical industrial channel. In such channel, a component supplier is selling a component to an OEM, and the OEM is selling its product to an indirect industrial buyer. The authors examine how component supplier's increased brand differentiation helps the component supplier to claim higher value from the OEM, in the OEM and indirect industrial buyer relationship, depending on uncertainty conditions. They have found out when the component supplier tries to leverage its brand to increase its profit, the OEM responds by aligning or opposing. When the OEM is free riding on the supplier's brand, the OEM will align itself with the higher marketing efforts of the component supplier. However, when the OEMs profit is threatened by the increased marketing efforts of the component supplier in the market, the OEM starts to shift its investments to counter balance it. For example, the OEM develops a different design that requires other components. These effects are moderated by both market and performance uncertainty.

Claiming the jointly created value is one of the cornerstones of GVA paradigm. Performance contracting is a means to claim the jointly created value in an industrial buyer and seller relationship. In the next section, I will address the product performance contracts, PPC, in more details.

Product Performance Contracts

Warranty promises in B2B markets are always negotiated. A part of a contract in any B2B transaction in general, and in the case of an OEM and its suppliers, in particular, may include product performance expectations. Such provisions in the contracts are close counterparts of warranties of the B2C markets.

Nevertheless, to the best of my knowledge, till date the concept of the product performance contracts (PPC) has not been explicitly studied. Also, the concept of contract specificity has not been examined in the context of product performance portion of the contracts. The theoretical gap is complimented by industry trends that have seen a general move from specification based contracting to performance-based contracting (Vargo & Lusch, 2004). In the specification based contracting the focus of the contract is on detailing and controlling for variation in the inputs, such as product design or component material. Whereas in the performance-based contracting, the parties, the buyer, and the seller focus more on the desired output characteristics of the product or the service at hand. In this new paradigm, the seller is relatively free in choosing the desired design of the inputs but still has to provide the requested output characteristics of the product, in the known working conditions.

The closest literature with some overlaps to PPC is the service literature. Some scholars view the term services inclusive of both product and service (Vargo & Lusch, 2004). To them, the focal point of exchange is service even in industrial buyer and seller settings. In this view, even the product is a part of exchanging a service. Vargo and Lusch (2004) define the term service as follow: “the application of specialized competences (skills and knowledge), through deeds, processes, and performances for the benefit of another entity or the entity itself (self-service)—that is intended to be inclusive”. In this perspective, manufacturing can be seen as a service and its output as a service provision. Davies, Brady, & Hobday (2007) even regard OEM companies as system integrators that their role is to coordinate the integration of components supplied by other external firms.

In a multitask principal (manufacturer) and agents (supplier) model, Kim, Cohen, & Netessine (2007) look at the implications of the performance based relationship in a supply chain. Their model is not inclusive of the product and only focuses on the after-sales services. In this paper, the authors study the availability of the spare parts for a customer. The manufacturer needs to have proper contracts with the component, i.e. part, suppliers. Authors are able to show that when channel members are risk averse, a combination of a fixed payment, cost-sharing incentives between the channel members, and performance incentives, i.e. availability of the parts, is an optimal form of contract. When the manufacturer is more (less) risk-averse than the suppliers, cost sharing incentives increases (decreases) while performance incentives decrease (increase) with time.

In an empirical paper, (Parisi, 2004) have looked at the performance contracting on the product reliability. Authors have contrasted the efficiency of two different contracting methods: time and material contracting (T&MC) and performance-based contracting. Their context of the study is the maintenance of the airplanes as an after-sales service. Using a two-stage model they show that performance-based contracting offers superior product reliability. The higher reliability is because of more frequent scheduled maintenance and higher quality maintenance each time. This paper highlights the service portion of the exchange more than the product portion.

Looking at PPC as another service component of the exchange, one may think of warranties as a tool to address the product performance issue. There is a large body of literature which looks at product performance through the lens of warranties. However, neither is the application of warranties limited to the product performance insurance nor are warranties a general tool to address a product performance issue in all contexts. There are other applications for warranties such as signaling the quality or sorting the buyers for example. Moreover, this literature is largely focused on consumer markets and does not capture the complexities of industrial markets. In the next section, I will examine warranty literature in more details.

Warranty

Literature of law and economics suggests that a warranty can be regarded as a promise of seller to buyer to assume some specific responsibilities if the performance or the quality of the purchased item does not meet up with the specifications and legitimate expectations of the buyer. Such promise can fall into two categories conventional warranties or legal ones. Conventional warranties are usually stipulated into the contract by both parties of the exchange before the transaction. Legal warranties however, are mandated by specific laws (Parisi, 2004). For this reason, conventional warranties are more subject to scrutiny as they may vary based on several factors and variables, and study of such variables can add our knowledge about the situations where they work best for sellers and buyers.

Warranties are the means to different ends. The functions of warranty can be different. Such different functions are regarded as insurance, signaling, incentive (Kubo, 1986; Matthews & Moore, 1987; Padmanabhan & Rao, 1993) and sorting (Kubo, 1986; Matthews & Moore, 1987; Padmanabhan & Rao, 1993). However, warranties can be very comprehensive or less comprehensive. Level of comprehensiveness can vary continuously in a spectrum from no warranty to full warranty. For simplicity different discrete levels of warranty can be imagined in a spectrum as: no warranty, partial warranty and full warranty. Then need for a conventional warranty can be justified based on a) sellers and buyers attitude towards risk, b) probability of product break down, and c) private information of either side of the contract.

Insurance function of a warranty depends on the buyers and sellers attitude towards risk. If both parties were risk neutral or even risk taker the pursuit of warranty as insurance would be meaningless. If both parties know that the probability of product failure is not zero insurance function of warranty can be useful. In such circumstances, full warranties will be favorable for risk averse buyers and no warranties for risk averse sellers. If both parties are risk averse they will agree on a partial warranty. Such partial warranty is the same conventional warranty that was mentioned earlier.

Signaling function of a warranty is dependent on asymmetry of information between buyer and seller. If both buyer and seller have symmetric information about the product at hand, the application of signaling function will be meaningless. Such function is relevant and important where there is an information asymmetry. In a case that seller has private information about the products quality and hence buyer has no information, full warranties are favorable choice of seller to signal the quality or the performance of the product to the buyer. When buyer has private information about the product i.e. the risk of ownership of such product and costs associated with it, no warranty is needed. In a more probable case where both parties have some private information about the product, partial warranty would be a mutual choice.

Another function of warranty is an incentive function. The risk associated with the failure of a product is not dependant on the product quality only; it is also affected by the behavior of each party towards the product. An example of such behaviors can be the maintenance efforts. In an extreme case where the risk of break down is not related to either’s party behavior, incentive function of the warranty is meaningless. However, when a seller can control risk of failure, the seller is willing to offer full warranty. In this circumstances warranty plays an incentive role for the seller to invest in products quality. Also, when a buyer has the full control over the risk, the buyer will not demand a warranty and warranty is not needed. In a moderate case where both the seller and the buyer will observe precaution in dealing with the product, a partial warranty can be meaningful.

Another function of warranties is sorting theory. Whenever buyers are similar in their evaluation of product quality and risk of failure sorting function of warranties is not plausible. But a seller can sort its buyers according to the buyers' differences in evaluation of risk of failure, and quality of product. This function of warranty stipulates that buyers with higher evaluation of quality and also with higher degree of risk aversion are willing to pay more for full warranties, while others are satisfied with partial warranties. Sorting function of warranties also helps sellers to maximize their profit with offering different warranties for the same product.

Table 2-2 summarizes the relationship between risk attitude of each party, information asymmetry and influence of the parties on the probability of failure occurrence with different functions of warranty as insurance, signaling, and incentive.

Table 2-2. Choice of Warranty Type

Adopted and Further Developed from (Parisi, 2004)

	Full Warranty	**Partial Warranty**	**No warranty**	**Warranty does not matter**
Insurance	Buyer is risk averse	Both parties are risk averse	Seller is risk averse	Both parties are risk neutral or risk taker
Signaling	Seller has private information Buyer has NO private information	Both parties have private information	Buyer has private information Seller has NO private information	There is information symmetry
Incentive	Seller can control risk	Both parties act with precaution	Buyer can control risk	Risk is exogenous
Sorting	Extended Warranties Heterogeneity in buyers' evaluation		Basic Warranty Homogeneity in buyers' evaluation	

Time in warranties - Both conventional and legal warranties have a time limit. This means time limit is generally a part of contract between seller and buyer (Chu & Chintagunta, 2011). Warranty period is therefore one of the important parameters in the choice of warranties.

Type of warranties - Warranties can be categorized in two different groups, basic/base warranties and extended ones. Extended warranties may include longer warranty period or include bigger scope. The main difference however, is that basic warranties are usually incorporated into the product. Therefore, basic warranties cannot be segregated from the product itself. Another difference is that basic warranties are usually offered by the seller or supplier, in comparison with extended warranties which can be offered by a third party such as a wholesaler/retailer, a dealer as well as the original supplier/manufacturer itself. (Kelley & Conant, 1991). The application of extended warranties seems to be limited to insurance and sorting applications among manufacturers and retailers/dealers (Chu & Chintagunta, 2011) while application of basic warranties may include any of known functions of warranty such as insurance, signaling, incentives and sorting (Chu & Chintagunta, 2011). In Retailing, where the important source of profit is retailer/dealer, they have an important role in selling extended warranties for durable goods, for example in consumer electronics market. In some other durable goods, where manufacturers may deal with the costumer directly, extended warranties are offered by manufacturer and such warranties are a profitable segment of the business, examples of such direct offerings can be seen in computer server market and in automotive industry (Chu & Chintagunta, 2011) .

Some of the characteristics of basic warranties are: service response time and warranty duration. However, differentiation across different products of a same seller usually occurs in warranty duration (Balachander, 2001; Soberman, 2003). This implies that warranty duration is a good measure to analyze different theories of warranty for both basic and extended warranties.

The literature on warranties considers functions such as signalling (Parisi, 2004), incentive (Padmanabhan & Rao, 1993) and sorting (Moorthy & Srinivasan, 1995) more relevant for consumer markets, and less relevant for business markets. In business markets as contrasted with consumer markets, the buyer and seller firms have less information asymmetry, so the signalling theory is less applicable. Moreover, in industrial cases, where the buying firm is not the consumer of the product, such as our context of MCS, the incentive function of the warranty is less applicable. Also, in business markets, firms have less heterogeneity in evaluation than consumers have, as a result, the sorting function of the warranties become less applicable. Among all functions of warranty, the insurance is the most applicable function in business markets. The firms, the seller and the buyer, can still be risk averse. The literature also investigates the insurance function for warranties (Mooi & Ghosh, 2010) in the consumer market, and none of the papers is laid out in an industrial setting.

While the basic functions of warranties are still relevant, though at a varying degree, in an industrial exchange, the intended functions are realized by detailing the performance expectations in the procurement contracts. Moreover, the legal grounds of warranties cover consumer markets only. As a result, warranties, as a tool of governing the transaction, are more relevant to consumer markets and less applicable in business markets. So there is a gap in the literature in assessing the product performance assurance in the business markets.

On the other hand, there is a trend in industrial markets, where industrial contracts are moving from input or design specifications based contracting to output or expected performance based contracting. This trend is widening the gap in the industrial marketing research even further. In the next section, the product performance contracts are discussed.

Literature Gaps

Table 2-3 summarized the related literature on the contractual relationship in a context that by definition is representative of multi-component systems. The major findings of literature review are as follows. Literature does not distinguish Product Performance Contracts from general procurement contracts in any industrial settings, including multi-component system industries. Also, the very specific literature gaps are as follows: A) The antecedents of Product Performance Contract Specificity are not known in the literature. Marketing literature has only explored the role of transaction specific investments and technology uncertainty on procurement contract specificity. B) The impact of misalignments from optimal contracting is a understudied domain. The role of misalignments on contract monitoring cost has not been investigated before. There not any studies to comprehensively study three types of transaction costs as contract writing cost, monitoring cost, and dispute cost. C) The impact of inevitable ex-post contracting costs such as disputes between the OEM and the component supplier on product performance has not been studied before. Most of the literature has only a transactional efficiency model in mind, without exploring the other consequences of such transaction costs on other aspects of performance. As a result, the context of Multi-component systems is an ideal context to investigate the antecedents of product performance contract specificity, given the interdependencies of the components in these systems. Figure 2-1 illustrates the identified gaps clearly. There are three important literature gaps that this study attempts to bridge.

Table 2-3. Representative Literature on Product Performance Contracts, PPC, and Multi-component System, MCS

	Source	PPC Examined	TYPE OF CONTRACTS STUDIED	ASPECT OF MULTI-COMPONENT SYSTEM EXAMINED	HYPOTHESES	DATA	KEY FINDINGS
1	Crocker & Reynolds, (1993)	NO	Incomplete Contracts	(NONE) Air Force Engine Procurement	Degree of contractual completeness is chosen to minimize the cost of contractual exchanges	Air Force Engine Procurement Longitudinal Contracts (1972-1991)	Find Support to the key Hypothesis.
2	Cannon, Achrol, & Gundlach, (2000)	NO	Legal Bonds	(NONE) Buyer and Seller Relationship	Increasing the relational content of a governance structure containing contractual agreements enhances performance when transactional uncertainty is high, but not when it is low.	(n=396) Buyer – Seller Relationships	Find Support to the key Hypothesis.
3	Wuyts & Geyskens, (2005)	NO	Detailed Contract	(NONE) Industrial Purchasing	Contracting becomes effective only when a nonclose partner is selected and when the focal relationship is embedded in a network of close mutual contacts.	(n=838) small to mid-size companies in Netherland.	Find Support to the key Hypothesis.
4	Ghosh & John, (2005)	NO	Complete vs. Incomplete	(NONE) Buyer and Seller Relationship	OEM's Strategy and resources moderate the role of investments and governance on performance.	(n=193) OEMs exchanging with independent component suppliers.	Investments must be aligned with more complete contract terms to yield cost reduction outcomes for all firms. However,

							investments must be aligned with more incomplete contracts to yield end- product enhancement outcomes, but only for firms with relatively small downstream market margins.
5	Ghosh, Dutta, & Stremersch, (2006)	NO	Level of Customization	(NONE) Buyer and Seller Relationship	Appropriate level of vendor control over the customization decision is a function of technology and knowledge considerations.	(n=304) Procurement arrangement for customized products.	Contracting parties choose the level of vendor control over customization in a strategic and discriminating way to enhance the benefits from customization for both parties.
6	Mesquita & Brush, (2008)	NO	Contract Completeness	(NONE) Buyer and Seller Relationship	The extent to which such mechanisms prevail as safeguards or coordination devices varies with the moderating effects of complexity and asset specificity.	(n=239) survey of suppliers.	At lower levels of specificity, and higher levels of complexity, the coordination logic of formal and informal governance matters more than the safe-guard logic—that is, governance mechanisms yield more production than negotiation efficiencies. Likewise, at lower levels of

							complexity and higher levels of asset specificity, the safeguard logic matters more than the production coordination logic (i.e., formal and informal governance mechanisms yield more negotiation than production efficiencies)
7	Ghosh & John, (2009)	NO	Branded vs. White-Box Comp. Contract	Industrial Purchasing	Leveraging the vendor's brand reputation and safeguarding the vendor's customization investments are key motivators for choosing branded component contracts.	(n=191) Contracts from three engineering-intensive industry sectors.	Find Support to the key Hypothesis.
8	Poppo & Zhou, (2014)	NO	Contractual Complexity	(NONE) Buyer and Seller Relationship	Whether fairness accounts for the effects of contractual complexity and contractual recurrence on exchange performance.	(n=283) buyer-seller dyads	Procedural fairness partially mediates the effect of contractual complexity, whereas distributive fairness partially mediates the effect of contractual recurrence in fostering exchange performance.
9	Sande & Haugland, (2015)	NO	Formal Contracting	(NONE) Buyer and Seller	Examines the effects of misaligned formal	(n=305) buyer–supplier relationships in the	(1) Misalignment has a significantly stronger

		Relationship	contracting on two types of outcomes, i.e., end-product enhancements and cost reductions, and on one mechanism through which misalignment affects performance, i.e., relational contracting.	Scandinavian wood industry	negative effect on end-product enhancements than on cost reductions, and (2) Relational contracts mediate the effect of misaligned formal contracting on performance.

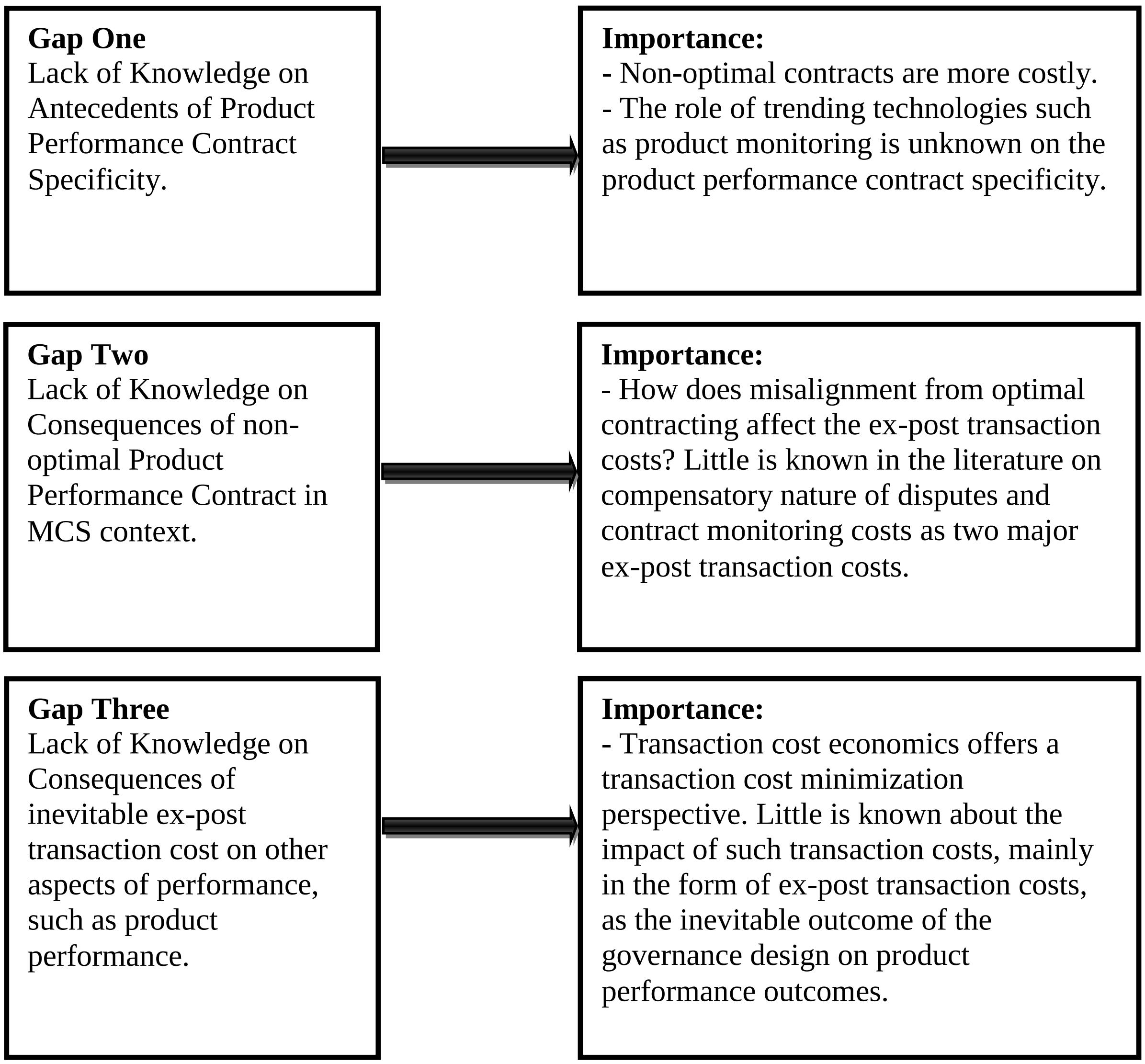


Figure 2-1. Identified Gaps in the Literature

Chapter Three Exploratory Field Work

The existing marketing literature does not offer a compelling explicit guidance to our understanding of how industrial buyers and their suppliers organize product performance contracts in the MCS context beyond the procurement contracts. In these contexts, ex-ante contract writing cost, ex-post contract monitoring cost, and ex-post failure disputation cost assume significance. That is in part because of the nature of the architecture of MCS, interrelations of the components, the technological uncertainties involved, and the nature of the relationship between the industrial buyer and supplier of the components. In this chapter, I will review the observations from the field that provide evidence to the existence of key constructs in this research. Those are contract specificity, different ex-post transaction costs, disputes, and monitoring technology. The latter is specifically important because new technologies to monitor product performance have made their way as an instrument in the contracts to guarantee performance.

Anecdotal Evidence of the Constructs

Transaction Costs

In an effort to examine the external validity of our disputation and monitoring concepts, field interviews with engineering firms have been conducted. In one example, an HVAC solution provider company has been studied. This is an example of an industrial buyer, or an OEM, which buys components and assembles them in order to sell them to consumers for utilization. The marketing manager acknowledged that disputes with suppliers over defective parts, or components, which are used in a multi-component system usually, constitute a big challenge for his department. Although, much of the disputes are resolved by negotiating, i.e. private ordering, such resolutions are still time consuming and costly. He also mentioned that the concept of contracts for over the counter products is usually downgraded to receipt of purchase. Whereas for most of other more complex parts, email conversations and agreements set the ground for the transaction. He also brought up the point that for newly designed parts, they, as the multi-component system assembler, would require the supplier provide different promises in writing about the performance of the component. This is the notion that is referred to performance contracting in this research. He also mentioned that whenever smart technologies allow for remote performance monitoring of their system in the customer site, there is usually less dispute over the performance of the components with the customer and the suppliers.

In another industrial example, i.e. in the power generation industry, power plant owners sign long-term service agreements, or LTSA, with a contractor. In this context, the owner of the plan is the industrial buyer. The service provider is the supplier of the services. The plant manufacturer is the supplier of the plant machinery. The owner is combining these two components, i.e. machinery and the services, to produce power and market it to the consumers. In this specific example, the power plant owner has added or modified clauses in a draft contract proposed by the contractor. In the following excerpts from an actual confidential contract, the owner is evidently pushing for higher contract specificity, by adding extra terms, to limit the ex-post disputes and facilitate ex-post contract monitoring. It is done, despite the extra cost of contract writing born ex-ante.

Power Plant Owner Increases Specificity to Facilitate the Monitoring.

Power plant owner, in an effort to enforce the higher contract performance by the suppler, is adding a clause which facilitates the product performance monitoring.

1) "… Owner Testing Rights: Notwithstanding anything in sub-clause X.X.Y to the contrary, Owner hereby specifically reserves the right, but shall not be obligated, to perform or have performed by an independent consultant (not to be a direct competitor of Contractor or its Affiliates), at Owner's expense, any test or tests on any Part prior to or after any Outage or other Maintenance Work. Contractor shall be notified in advance of any tests to be performed on such Part and may be present or represented during such tests. Upon request by Contractor, Owner shall discuss such testing and provide reasonable access to the data from such testing. In the case that any such test is performed on a repairable Part (i.e., with life remaining), but is destructive in nature, Owner shall authorize Contractor to provide a replacement Part as Additional Work."
2) "… Owner's Inspection Rights: Owner reserves the right, but shall not be obligated, to appoint inspector(s) to inspect any Part of the Gas Turbine either

before installation, or after it has been removed therefrom, and to follow the progress of the Work at the Site and in the Contractor's repair facilities, subject to applicable policies and procedures, provided that such inspectors shall not be direct competitors of Contractor or its Affiliates and provided that such inspectors first execute a confidentiality agreement with terms substantially similar to those set forth in clause X. If the actions of the inspector impact the schedule and/or cause an increase in cost to perform the work, Contractor shall be entitled to any corresponding schedule relief and/or payment from Owner to the extent that Contractor demonstrates any such delay in schedule and/or increase in costs."

3) "….Contractor shall furnish Owner all final reports on the results of any such analysis performed by Contractor (including any RCA), and shall respond in a prompt and timely manner to Owner's technical inquiries regarding the same."

<u>Power Plant Owner Increases Specificity to Limit the Disputes</u>

1) "… contractor shall deliver all needed Parts to the Site not less than thirty (30) Days prior to scheduled commencement of each Planned Maintenance inspection (in accordance with the then-current Maintenance Program). Contractor shall notify Owner not less than seventy-two (72) hours following Contractor's shipment of any Parts (regardless of whether being utilized during a Planned Maintenance event or during Unplanned Maintenance) of the anticipated delivery dates of such Parts to the Site. Contractor shall provide Owner with such Quality Assurance Documents as may be necessary for Owner to perform, and shall be on

Site upon the arrival of such Parts and shall provide reasonable assistance to Owner in performing an inspection of the Program Parts as provided in the foregoing paragraph. For purposes hereof, ("Quality Assurance Documents") shall mean, with respect to Parts, information and documentation reasonably necessary to demonstrate that such Parts have passed necessary quality assurance programs and criteria of Contractor, such as flow test data as applicable and certifications by Contractor (with respect to refurbished parts) and that such Parts have been refurbished in accordance with Contractor's or Affiliate Company's repair standards. "

2) "… contractor shall not use Contract Parts in any gas turbine outside the Facility nor shall Contractor use any Contract Parts from another power plant at the Facility."

These findings from the field certainly highlight the significance of the ex-post governance costs, i.e. the disputation and the monitoring costs. Moreover, managing these costs, or accounting for these costs in the contract ex-ante, receives significant managerial attention. Finally, the relationship between the constructs suggests a strong directionality between contract specificity and ex-post governance costs.

Product Performance Contract Specificity

I found some evidence that the degree of contract completeness can vary considerably depending on some factors. For example, the manager in the HVAC company acknowledged that they, as a supplier of steam heat exchangers and solution provider in this domain, usually stay away from Oil and Gas industrial customers. He reasoned that the number of industrial regulations in Oil and Gas companies was significantly higher than any other industry. Given their organizational resources, he mentioned, they have decided to stay out of that industry, because managing contracts with their suppliers are much more elaborated in that industry. He also gave different examples of contracts with suppliers at varying degrees of the specificity. Some of the components are procured over simple email transactions while other components are sourced by very formal components.

In the example of power generation industry, the confidential contract that we were presented with indicated multiple runs of negotiations. In each round of negotiations some items were either added or deleted from the proposed contract by the owner, depending on the discussions with the service provider.

<u>Product Performance</u>

We also witness supporting evidence that the HVAC company relates some of the performance requirements of the user to the contracts with the supplier in the upstream. For example, in the case of a heating solution in one university in Ontario, the focal HVAC solution provider firm had related the output requirements of the steam flow to the contract with the boiler supplier.

Similar mandates in the contracts are also evident in the LTSA agreement that I have probed. There, the owner requests the service provider to maintain certain ranges of power output under the different regimes of electricity demand. These examples provide evidence of product performance contracting in two different industries.

Chapter Four Theory

Marketing literature is not well developed around the compensatory notion of individual transaction costs. TCE literature is specifically silent about the compensatory nature of ex-post costs. One can expect governance efficiency losses if the compensatory nature of governance costs is not accounted for. To build a theory in this domain, I dissect the relationship between a manufacturer of a typical multicomponent system with one of its component suppliers in the most general form, using the transaction cost economics lens. I will refer to the evidence from the field to sharpen our understanding of important constructs and relationships. Then, I propose a descriptive model to characterize the different constructs in the exchange relationship between the manufacturer and its supplier. Finally, by studying the relationships between the constructs, I attempt to generate some testable hypotheses.

Conceptual Development

I envisage the relationship of an industrial buyer, an OEM or a manufacturer or an MCS, and its suppliers of the components as follow. Industrial buyers and sellers, OEMs and their suppliers in this case, face competing incentives when negotiating PPCSpec. On one hand, both parties of any given transaction can agree to write highly specific performance contracts. Such contracts may entail high ex-ante costs of writing complete contracts for both sides. Writing complete contracts are costly, because of incomplete information. When seeking for more complete information, to tackle the uncertainties and contingencies, a firm has to invest more in the resource to do a thorough research. OEMs may also face high ex-post costs of monitoring such highly specific contract if they wish to enforce the detailed requirements. Monitoring a contract and other parties' compliance with the agreed terms of contract can be costly. It can become even more costly as the number of components in the MCS rise. It becomes even costlier when the interaction of the components with each other adds on to the complexity of the monitoring task. On the other hand, both parties may choose to write generic contracts with minimal specificity. One example of such contracts would be "Memorandums of Understanding". In that case, both parties may incur high disputation cost ex-post, in the form of renegotiations if a component fails. Disputation cost may include the cost of renegotiating the contract terms, liabilities caused by a failure, or spending time to find a remedy when a failure happens. This cost includes the costs associated with private ordering, and ultimately with court ordering. Such ex-post disputations can be costly for all parties if the nature of the technology and the interdependency of the components make it difficult to converge on a commonly agreed characterization of the failure and its impact. For example, it would be difficult for the OEM and the supplier to converge on a solution, if they are unable to attribute the cause of a component failure to the performance of another component, or to an inherent defect in the failing component. As a result, parties may seek to initially negotiate a proper level of contract details, or contract specificity (Eisenhardt, 1989). A proper level of contract specificity imposes minimal contract costs on them both ex-ante and ex-post.

One may argue that monitoring a contract can cause disputes between the industrial buyer and seller because the buyer may find discrepancies in the compliance of the supplier to the contract. Thus, one may claim that there is an endogeneity present in the monitoring cost and the disputation cost relationship. Note that the magnitude of the disputes raised by contract monitoring is assumed to be far less than the disputes over a major performance failure. Moreover, monitoring can also provide the necessary insight for resolving disputes once a performance shortcoming materializes. As a result, there should be less dispute cost. Thus, I do not anticipate any endogeneity between monitoring and disputation conceptually. Nonetheless, in our context, monitoring and disputes could be positively or negatively correlated.

By adopting the perspective of the principal-agent theory in industrial buyer and seller relationship (Heide, 2003), one can regard the OEM as the principal and the supplier as an agent in these settings of exchange. The principal is the one which offers the initial draft of the contract. The agent may choose to take the offer or leave it. Adopting this perspective is not unprecedented in the literature, few notable examples are (Kashyap et al., 2012) in the buyer-seller relationship and (Ghosh et al., 2006; Stremersch et al., 2003; Wilson et al., 1990) in the franchisor-franchisee. Although, in B2B markets, most transactions are negotiated over the terms and the price, one can assume that such negotiations are in fact to fine tune the contract terms, after the supplier agrees to take the offer from the buyer. If the supplier decides not to take the offer, there is no room for negotiation in the first place.

Adopting a Principal Agent perspective simplifies our process of explication by invoking a sequential accept or reject decision making framework. An alternative equilibrium framework where both parties offer transaction cost minimizing design parameters either simultaneously, or sequentially, would offer similar insights but would come at enhanced cost of complexity. The alternative perspective in this case would be two individual firms approaching each other with an initial idea about their optimum contract specificity. During negotiations in order to achieve an agreement and hence a contract, both parties can only agree to a level of contract specificity in the range defined by their own earlier preferences. Nonetheless, the buyer only agrees to a level of contract specificity that still keeps the total governance costs low, if not absolute minimum. However, it is possible to achieve similar results with the principal-agent perspective, assessing the principal only. Same as the alternative explanation, the principal seeks to minimize the total governance costs. As a result, I continue to use the principal-agent perspective.

Descriptive Model

When the principal drafts the contract, and offers it to the agent, in fact the principal is choosing an appropriate level of product performance contract specificity. This optimal level of product performance contract specificity, denoted as S*, should minimize the total governance cost of the exchange with the supplier, denoted as G. The principal is faced with different cost functions that together make up the governance cost

G. Those cost functions are ex-ante contract writing cost, W, ex-post contract monitoring cost, M, and ex-post disputation cost, D. I assume the contract writing cost is a function of product performance contract specificity, and a shift parameter, $W=W(S, X_W)$. Also, I posit each of the monitoring and disputation costs is a function of product performance contract specificity and a shift parameter, $M = M (S,X_M)$ and $D = D (S,X_D)$. The principal may choose higher levels of S to contain ex-post disputes but at the same time faces higher need to extend it contract monitoring efforts. By the shift parameters X_W , $X_{M,}$ and X_D, I mean all the exogenous variables that can change the contract writing, monitoring, and disputation costs, respectively, at any given level of specificity. For example at a given level of the product performance contract specificity, a firm, which owns a product with monitoring capabilities of the components, can monitor the performance of the product at a lower cost than a firm that lacks this technological setup. In this example, X_M is the technological capability to monitor the product. Here is another example. At a given level of the product performance contract specificity, a manufacturer firm with a more modular product at hand can more easily diagnose the root of a component failure and limit the disputes with the supplier of the faulty component. Modular products or systems are characterized by clearer interconnect boundaries of components (Ghosh et al., 2006; Stremersch et al., 2003; Wilson et al., 1990). However, a manufacture firm with an more integral, or less modular, product at hand has to go through more extensive disputes with more suppliers to find the cause of the failure. In this example, both X_M and X_D are related to product modularity. Overall, I attribute a number of exogenous variables to both shift parameters.

To assess the relation of product performance contract specificity and shift parameters in the two main cost curves, i.e. disputation and monitoring, a general function can be constructed. This general function will show how the product performance contract specificity will change with respect to the changes to any shift parameters. Table 4-1 illustrates different variables used.

Table 4-1. List of Variables in the Model

Variable Name	**Description**
D	Disputation Cost – ex-post
M	Monitoring Cost – ex-post
W	Contract Writing Cost – ex-ante
G = D + M + W	Governance Cost, i.e. Total Transaction Cost
S	Product Performance Contract Specificity
X_D	Positive Shift Parameter for Disputation Cost, D
X_M	Positive Shift Parameter for Monitoring Cost, M
X_W	Positive Shift Parameter for Contract Writing Cost, W
X	Positive Shift Parameter for Multiple Transaction Costs

I think of total governance cost, as a summation of each posited cost element, i.e. contract writing cost(Antia & Frazier, 2001; Cannon & Homburg, 2001; Dahlstrom & Nygaard, 1999; Heide, Wathne, & Rokkan, 2007; Houston & Johnson, 2000; Kashyap et al., 2012), Contract Monitoring Cost (Crocker & Reynolds, 1993), and Disputes (Williamson, 1985) , G = D + M + W. I elaborate on the properties of each transaction cost below.

Characterizing Ex-post Dispute Costs

The magnitude of the disputation cost goes down with an increase in S, since greater specificity aids dispute resolution easier, $\frac{\partial D}{\partial S} < 0$. That is because at higher levels of specificity more contingencies are thought of and included in the contract. This assumption is certainly similar to the predictions of TCE where contracts are regarded as governance mechanisms to safeguard investments (Williamson, 1985). Here, I am extending TCE's predictions to the realm of PPC, by assuming that more complete contracts should help firms avoid future costs in the form of disputes and negotiations to settle a failure case. The marginal impact of S decreases when specificity increases. That is because contracts are necessarily incomplete due to the bounded rationality, so I expect $\frac{\partial^2 D}{\partial S^2} > 0$. In other words, an increase at the level of product performance contract specificity is more impactful to reduce disputes at low levels of product performance contract specificity than higher levels. Without any loss in generality I have assumed that X_D is a positive shifter of dispute cost, D. Disputation cost goes up with higher levels of X_D, $\frac{\partial D}{\partial X_D} > 0$. This assumption is completely general and one can also think of a parameter $X_D^1 \propto \frac{1}{X_D}$ which would have a negative slope. The impact of the shift parameter, X_D, on D is due to processes that increase the cost of dispute resolution. It seems reasonable to assume that the higher level of product performance contract specificity, S, will reduce the salience of these processes, thereby, reducing the impact of

X_D on D, $\frac{\partial^2 D}{\partial S \partial X_D} < 0$. In other words, disputation cost becomes less sensitive to the changes of X_D as the level of product performance contract specificity increases.

In a similar context to MCS, Crocker & Reynolds, (1993), argue that the prior history of disputes with business partners are an indication of supplier's opportunism, and that the buyer engages in more stringent contracts in the next transaction. Opportunism is a key variable in Williamson's, (1985), transaction cost economics paradigm. Therefore, one application of more specified contracts is to decrease the level of ex-post disputes from the level that the buyer has already experienced with the supplier. This assumption is certainly similar to the predictions of TCE where contracts are regarded as governance mechanisms to safeguard specific investments (Williamson, 1985). Moreover, Wuyts & Geyskens, (2005), also find empirical support for the their hypotheses that detailing a contract reduces partner's opportunism. Thus, reduced levels of opportunism should translate into lower disputes with the business partner. In a different context of IT investments, Mooi & Ghosh, (2010), propose that ex-post transaction problems are negatively correlated with over-specified contracts. Their measurement of ex-post transaction problems excludes any measurement of monitoring cost. As a result, their definition of ex-post problems is in line with our conceptualization of ex-post disputes. That is because I see disputes as the consequence of such ex-post problems. While they fail to empirically show that ex-post problems are negatively correlated with contract specificity, they find empirical support that over-specified contracts are associated with lower ex-post problems. Also, (Crocker & Reynolds, 1993)) show that the contractual governance structure is negatively correlated with interfirm dispute resolution, i.e. cost of the dispute resolution.. Subsequently, I assume that disputes are negatively associated with contract specificity in the context of MCS.

Moreover, the marginal benefits of reduced disputes when devising more complete contracts is decreasing (Crocker & Reynolds, 1993). Therefore, I also assume $\frac{\partial^2 D}{\partial S^2}>0$.

The examples of positive shift parameters of dispute cost, i.e. $\frac{\partial D}{\partial X_D}>0$, are OEM's transaction specific investments (Ray, Bergen, & John, 2016)) and OEM's mixing and matching of branded components in the absence of any constraints by the component suppliers (Ray, Bergen, & John, 2016). At any given level of contractual completeness, when the OEM invests in transaction specific investments, the probability of engaging in ex-post disputes increases- considering the opportunism of the supplier. Likewise, when the OEM freely mix-and-matches branded components the possibility of ex-post disputes increases. These two constructs serve as the examples of X_D. Moreover, the positive impact of such shift parameters diminishes at higher levels of contractual completeness. As a result, I assume, $\frac{\partial^2 D}{\partial S \partial X_D}<0$.

A1) about ex-post Dispute cost: $\frac{\partial D}{\partial S}<0$, $\frac{\partial D}{\partial X_D}>0$, $\frac{\partial^2 D}{\partial S \partial X_D}<0$

<u>Characterizing Ex-post Monitoring Costs</u>

The magnitude of the monitoring cost increases as the product performance contract specificity increases. It is because the buyer has more terms and conditions to monitor and the other party has more to comply with, $\frac{\partial M}{\partial S} > 0$. Greater specificity has an increasing impact on the monitoring and compliance costs. This is due to resource and cognitive limitations that are reached at a higher level of product performance contract specificity, $\frac{\partial^2 M}{\partial S^2} > 0$. In other words, as the product performance contract specificity increases the complexities of monitoring multiple terms of the contract, stipulated by product performance contract specificity, raise at an increasing rate. This is specifically reasonable to assume in the context of MCS, where the physical inter-dependability of the components affects the performance expectation of each component is stipulated in the contract. Without any loss in generality I have assumed that X_M is a positive shifter. M goes up with higher levels of X_M. This assumption is completely general and one can also think of a parameter $X_M^1 \propto \frac{1}{X_M}$ which would have a negative slope. The impact of X_M on M is due to processes that increase the cost of monitoring and compliance. These costs go up by an increasing factor at higher levels of $X_{M,}$ $\frac{\partial^2 M}{\partial S \partial X_M} > 0$. In other words, monitoring cost becomes more sensitive to the changes of X_M as the level of product performance contract specificity increases.

Heide, Wathne, & Rokkan, (2007), propose and find empirical support that output monitoring, unlike partner's behavior monitoring, reduces opportunism. On the other hand, Dahlstrom & Nygaard, (1999) show that formalization reduces opportunism. If we accept formalization as a proxy of contract specificity, I can then conclude that formalization and output monitoring, and hence the cost associated with output monitoring, are positively correlated. Also, (Ray et al., 2016)), argue that contractual completeness offers the principal, the OEM, a more straightforward platform to assess the agent's, the supplier 's, compliance to contractual terms. Logically, the cost of monitoring is positively related to the compliance monitoring. Subsequently, I assume that the cost of monitoring is positively related to contract specificity in the context of MCS.

In the context of MCS, interconnect standards and interoperability of different component brands contribute to complexity of the transactions between the OEM and supplier (Williamson, 1985). As the OEM increases the contractual completeness with one supplier, the marginal cost of monitoring increases too. That is because of the interplay of the focal component with other key components. As a result, I assume $\frac{\partial^2 M}{\partial S^2} > 0$.

One example of negative shift parameter of ex-post monitoring cost is monitoring technology, i.e. $\frac{\partial \mathrm{M}}{\partial X_{\mathrm{M}}^{1}}<0$. At any given level of contractual completeness, when the OEM invests in monitoring technology, the ex-post monitoring can be done at a lower cost. Moreover, the impact of such shift parameters is stronger, i.e. more decrease in monitoring cost, at higher levels of contractual completeness. As a result, I can assume

$\frac{\partial^2 M}{\partial S \partial X_M^1} < 0$. This is in line with our assumption of a positive shift parameter X_M, $\frac{\partial M}{\partial X_M}<0$, and $\frac{\partial^2 M}{\partial S \partial X_M} < 0$.

A2) about ex-post Monitoring cost: $\frac{\partial M}{\partial S} > 0,\ \frac{\partial M}{\partial X_M} > 0,\ \frac{\partial^2 M}{\partial S \partial X_M} > 0$

Characterizing Ex-ante Contract Writing Costs

First, I talk about the contract writing cost, W. It is more costly to write more specified contracts. The reason is that more administrative efforts have to be exerted, so I expect $\frac{\partial W}{\partial S} > 0$. This assumption is also supported by the predictions of TCE (Williamson, 1985). Greater specificity has an increasing impact on the contract writing cost. This is due to resource and cognitive limitations that are reached at a higher level of product performance contract specificity, as a result I expect that $\frac{\partial^2 W}{\partial S^2} > 0$. By construction, I think of X_W as a positive shift parameter. This assumption is completely general and one can also think of a parameter $X_W^1 \propto \frac{1}{X_W}$ which would have a negative impact on W. The positive impact of X_W on contract writing cost, W, i.e. $\frac{\partial W}{\partial X_W} > 0$ is by increasing the cost of information gathering and sense making. It is costly to write contracts when there is no complete information. The impact of X_W on W is due to the need to uncover information, which is costly in nature. At higher level of product performance contract specificity, S, it becomes even more difficult, and hence more costly, to write contract when the uncertainty about the performance of the component is also increasing, thus I expect $\frac{\partial^2 W}{\partial s \partial \mathrm{X_W}} > 0$.

Williamson, (1985), argues that in the absence of the complete information the buyer faces a high cost of drafting a contract, and as a result when the cost is too high vertical integration becomes a more efficient option. At the core of this argument, there is bounded rationality, and an understanding that gathering information is costly. Information is needed to write more specific contracts. Thus, more specific contracts are inevitably more expensive to write. There are not many papers which have examined this relationship empirically. However, in the context of IT investments, Anderson & Dekker, (2005), and (Crocker & Reynolds, 1993)) find the empirical support that more specified contracts require a higher upfront cost to draft them. Subsequently, I assume in the context of MCS, higher contract specificity is associated with higher contract writing cost.

The marginal cost of drafting a contract is increasing in the degree of contract completeness (Crocker & Reynolds, 1993; Ghosh & John, 2009) so I assume $\frac{\partial^2 W}{\partial s^2} > 0$.

One example of positive shift parameters of ex-ante contract writing cost, i.e. $\frac{\partial \mathrm{W}}{\partial \mathrm{X_W}}>0$, is technological uncertainty. At any given level of contractual completeness, when the OEM faces with higher technological uncertainty, the cost of writing the contract will be higher (Crocker & Reynolds, 1993; Ghosh & John, 2009). Moreover, the positive impact of such shift parameter increases at higher levels of contractual completeness. As a result, I assume, $\frac{\partial^2 W}{\partial S \partial X_W}$<0.

A3) *about ex-ante Contract Writing Cost*: $\frac{\partial W}{\partial s} > 0,\ \frac{\partial W}{\partial x_W} > 0,\ \frac{\partial^2 W}{\partial s \partial x_W} > 0$

<u>Independence of the Shift Parameters</u>

The shift parameters can be assumed independent of each other: $\left.\frac{\partial \mathrm{X_i}}{\partial \mathrm{X_j}}\right|_{i \neq \mathrm{j}} = 0, \{\mathrm{i}\&j \in \{\mathrm{D, M, W}\}\}$. Technological uncertainty acts as a shift parameter, X_W, for contract writing cost (Ghosh & John, 2005). Output monitoring acts as a shift parameter, X_M, for monitoring cost (Ghosh & John, 2005). Transaction specific investments act as a shift parameter, X_D, for dispute cost (Heide, 1994; Williamson, 1991). This assumption can be relaxed later without any loss in generality. I will relax this assumption in scenarios I and II below.

A4) *Independence of the shift parameters*: $\left.\frac{\partial \mathrm{X_i}}{\partial \mathrm{X_j}}\right|_{i \neq \mathrm{j}} = 0, \{\mathrm{i}\&j \in \{\mathrm{D, M, W}\}\}$

<u>Objective Function</u>

Following the agency theory, the OEM, the principal, incurs these costs and chooses S* to minimize the governance cost G, before offering the contract to the component supplier.

$$\{S^* : \underset{S}{\mathrm{Min}}\, G\,(D(S, X_D), M(S, X_M), W(S, X_W)\} \tag{4-1}$$

S* solves for the minimum, subject to satisfying the first and second order conditions. I write first order condition, FOC, as follows:

$$\frac{\partial G}{\partial S} = \frac{\partial D}{\partial S} + \frac{\partial M}{\partial S} + \frac{\partial W}{\partial S} = 0 \tag{4-2}$$

Assumption of a Well Behaved Objective Function

I am further assuming that the objective function, G, is well behaved, i.e. $\frac{\partial^2 G}{\partial S^2} > 0$. It is shown that the second order derivatives of all cost functions are positive with respect to S, i.e. $\frac{\partial^2 D}{\partial S^2} > 0$, $\frac{\partial^2 M}{\partial S^2} > 0$, and $\frac{\partial^2 W}{\partial S^2} > 0$. As a result, it is possible to show that $\frac{\partial^2 G}{\partial S^2} > 0$. That is because,

$$\frac{\partial^2 G}{\partial S^2} = \frac{\partial^2 D}{\partial S^2} + \frac{\partial^2 M}{\partial S^2} + \frac{\partial^2 W}{\partial S^2} > 0 \tag{4-3}$$

Thus, S* solves for the minimum. (Ghosh et al., 2006; Stremersch et al., 2003; Wilson et al., 1990) use similar transaction cost minimization paradigm by the industrial buyer, i.e. Air Force, albeit with respect to pricing schemes as the measure of contract specificity.

A5) *well behaved objective function G*, i.e. *Second Order Condition:* $\frac{\partial^2 G}{\partial S^2} > 0$

<u>Comparative Statics</u>

Once the model structure is justified, the rest of model deviation follows. One critical question here is: how does S* depend on X_D and X_M? To explore the role of shift parameters, i.e. X_D and X_M, I will use comparative statics. The choice variable here is S, and the exogenous shift parameters are X_D, X_M, X_W, $S(X_D, X_M, X_W)$, it is possible to rewrite equation (4-1) as follow.

$$\left.\frac{\partial G(S(X_D, X_M, X_W), X_D, X_M, X_W)}{\partial S}\right|_{S=S^*} = 0 \tag{4-4}$$

Differentiating both sides of equation (4-4), i.e. FOC, with respect to X_D, and X_M would results in (4-5) and (4-6) respectively:

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X_D} + \frac{\partial S}{\partial X_M}\cdot\frac{\partial X_M}{\partial X_D} + \frac{\partial S}{\partial X_W}\cdot\frac{\partial X_W}{\partial X_D}\right] + \frac{\partial^2 G}{\partial S\partial X_D} + \frac{\partial^2 G}{\partial S\partial X_M}\cdot\frac{\partial X_M}{\partial X_D} + \frac{\partial^2 G}{\partial S\partial X_W}\cdot\frac{\partial X_W}{\partial X_D} = 0 \tag{4-5}$$

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X_D}\cdot\frac{\partial X_D}{\partial X_M} + \frac{\partial S}{\partial X_M} + \frac{\partial S}{\partial X_W}\cdot\frac{\partial X_W}{\partial X_M}\right] + \frac{\partial^2 G}{\partial S\partial X_D}\cdot\frac{\partial X_D}{\partial X_M} + \frac{\partial^2 G}{\partial S\partial X_M} + \frac{\partial^2 G}{\partial S\partial X_W}\cdot\frac{\partial X_W}{\partial X_M} = 0 \tag{4-6}$$

Invoking to the independence of shift parameters, i.e. X_D, X_M, and X_W from the assumption, i.e. A4, I simplify equations (4-5) and (4-6), and re-write them as (4-7) and (4-8) respectively.

$$\frac{\partial^2 G}{\partial S^2} \cdot \frac{\partial S}{\partial X_D} + \frac{\partial^2 G}{\partial S \partial X_D} = 0 \Rightarrow \frac{\partial S}{\partial X_D} = \frac{-\frac{\partial^2 G}{\partial S \partial X_D}}{\frac{\partial^2 G}{\partial S^2}} \tag{4-7}$$

$$\frac{\partial^2 G}{\partial S^2} \cdot \frac{\partial S}{\partial X_M} + \frac{\partial^2 G}{\partial S \partial X_M} = 0 \Rightarrow \frac{\partial S}{\partial X_M} = \frac{-\frac{\partial^2 G}{\partial S \partial X_M}}{\frac{\partial^2 G}{\partial S^2}} \tag{4-8}$$

At $S = \quad {}^*$, $\frac{\partial^2 G}{\partial S^2} > 0$, hence:

$$\left.\frac{\partial S}{\partial X_D}\right|_{S=S^*} = \frac{-\frac{\partial^2 G}{\partial S \partial X_D}}{\left|\frac{\partial^2 G}{\partial S^2}\right|} \rightarrow Sign\left(\frac{\partial S^*}{\partial X_D}\right) = -Sign\left(\frac{\partial^2 G}{\partial S \partial X_D}\right) \tag{4-9}$$

$$\left.\frac{\partial S}{\partial X_M}\right|_{S=S^*} = \frac{-\frac{\partial^2 G}{\partial S \partial X_M}}{\left|\frac{\partial^2 G}{\partial S^2}\right|} \rightarrow Sign\left(\frac{\partial S^*}{\partial X_M}\right) = -Sign\left(\frac{\partial^2 G}{\partial S \partial X_M}\right) \tag{4-10}$$

From equations (4-9) and (4-10), $\frac{\partial^2 G}{\partial S \partial X_D}$ and $\frac{\partial^2 G}{\partial S \partial X_M}$ can be simplified as follow:

$$\frac{\partial^2 G}{\partial S \partial X_D} = \frac{\partial^2 (D+M+W)}{\partial S \partial X_D} = \frac{\partial^2 D}{\partial S \partial X_D} + \frac{\partial^2 M}{\partial S \partial X_D} + \frac{\partial^2 W}{\partial S \partial X_D} = \frac{\partial^2 D}{\partial S \partial X_D} + 0 + 0 = \frac{\partial^2 D}{\partial S \partial X_D} \quad (4\text{-}11)$$

Hence, $Sign\left(\frac{\partial S^*}{\partial X_D}\right) = -Sign\left(\frac{\partial^2 D}{\partial S \partial X_D}\right) > 0$, from earlier assumptions.

$$(4\text{-}12) \quad \frac{\partial^2 G}{\partial S \partial X_M} = \frac{\partial^2 (D+M+W)}{\partial S \partial X_M} = \frac{\partial^2 D}{\partial S \partial X_M} + \frac{\partial^2 M}{\partial S \partial X_M} + \frac{\partial^2 W}{\partial S \partial X_M} = 0 + \frac{\partial^2 M}{\partial S \partial X_M} + 0 = \frac{\partial^2}{\partial S \partial X_M}$$

Hence, $Sign\left(\frac{\partial S^*}{\partial X_M}\right) = -Sign\left(\frac{\partial^2 M}{\partial S \partial X_M}\right) < 0$, from earlier assumption of independence of shift parameters, A4. This leads to key propositions:

Proposition 1- $\frac{\partial S^*}{\partial X_D} > 0$: Factors that increase disputation costs lead to higher desired levels of product performance contract specificity.

Proposition 2- $\frac{\partial S^*}{\partial X_M} < 0$: Factors that increase monitoring cost lead to lower desired levels of product performance contract specificity.

To find out how S* reacts to the changes of X_W. I can take a derivative of both sides of equation (4-4), i.e. FOC, with respect to X_W.

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X_D}\cdot\frac{\partial X_D}{\partial X_W}+\frac{\partial S}{\partial X_M}\cdot\frac{\partial X_M}{\partial X_W}+\frac{\partial S}{\partial X_W}\right]+\frac{\partial^2 G}{\partial S\partial X_D}\cdot\frac{\partial X_D}{\partial X_W}+\frac{\partial^2 G}{\partial S\partial X_M}\cdot\frac{\partial X_M}{\partial X_W}+\frac{\partial^2 G}{\partial S\partial X_W}=0 \tag{4-13}$$

Invoking to the independence of shift parameters from the assumption, i.e. A4, I simplify equation (4-13), and re-write it as (4-14).

$$\frac{\partial^2 G}{\partial S^2}\cdot\frac{\partial S}{\partial X_W}+\frac{\partial^2 G}{\partial S\partial X_W}=0 \Rightarrow \frac{\partial S}{\partial X_W}=\frac{-\frac{\partial^2 G}{\partial S\partial X_W}}{\frac{\partial^2 G}{\partial S^2}} \tag{4-14}$$

At $S=S^*$, $\frac{\partial^2 G}{\partial S^2}>0$, hence:

$$\left.\frac{\partial S}{\partial X_W}\right|_{S=S^*}=\frac{-\frac{\partial^2 G}{\partial S\partial X_W}}{\left|\frac{\partial^2 G}{\partial S^2}\right|}\rightarrow Sign\left(\frac{\partial S^*}{\partial X_W}\right)=-Sign\left(\frac{\partial^2 G}{\partial S\partial X_W}\right) \tag{4-15}$$

From equation (4-15), $\frac{\partial^2 G}{\partial S\partial X_W}$ can be simplified as follow:

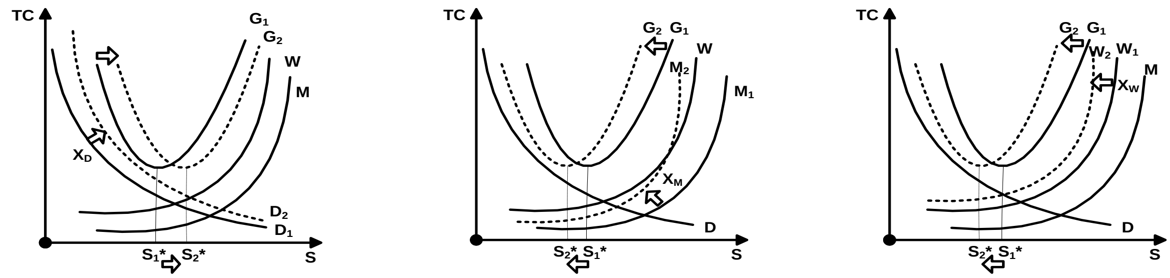
$$\frac{\partial^2 G}{\partial S\partial X_W}=\frac{\partial^2 (D+M+W)}{\partial S\partial X_W}=\frac{\partial^2 D}{\partial S\partial X_W}+\frac{\partial^2 M}{\partial S\partial X_W}+\frac{\partial^2 W}{\partial S\partial X_W}=0+0+\frac{\partial^2 W}{\partial S\partial X_W}=\frac{\partial^2 W}{\partial S\partial X_W} \tag{4-16}$$

Hence, $Sign\left(\frac{\partial S^*}{\partial X_W}\right) = -Sign\ \left(\frac{\partial^2 W}{\partial S \partial X_W}\right) < 0$, from earlier assumption of independence of the shift parameters, A4. This leads to another proposition:

> **Proposition 3-** $\frac{\partial \mathrm{S}^*}{\partial \mathrm{X_M}} < 0$: Factors that increase contract writing cost lead to lower desired levels of product performance contract specificity.

In the Figure 4-2, I have illustrated the intuition behind each proposition. Panel (a) illustrate the intuition behind an impact on dispute cost, by a shift parameter X_D, and the overall reaction of G, and consequently the change in the level of optimal product performance contract specificity, S*. Panel (b) illustrate the intuition behind an impact on monitoring cost, by a shift parameter X_M, and the overall reaction of G, and consequently the change in the level of optimal product performance contract specificity, S*. Panel (c) illustrate the intuition behind an impact on contract writing cost, by a shift parameter X_W, and the overall reaction of G, and consequently the change in the level of optimal product performance contract specificity, S*.

(a) Intuition Behind Proposition 1	(b) Intuition Behind Proposition 2	(c) Intuition Behind Proposition 3



G= Governance Cost, i.e. Transaction Cost, S= Product Performance Contract Specificity, D= Ex-post Dispute Cost, M= Ex-post Monitoring Cost, W= Ex-ante Contract Writing Cost, G=D+M+W= Total Governance Cost, S_1* and S_2*=Optimimum Product Performance Contract Specificity.

Note: The graphics are for illustrative purposes only.

Figure 4-1. Schematic representation of intuition behind Propositions 1 to 3

Relaxing the Independence of the Shift Parameters Assumption

Now, I relax the assumption of the independence of the shift parameters. The motivation behind relaxing this assumption is a variable that can impact both dispute and monitoring cost at the same time, such as modularity (Williamson, 1996). I will specifically illustrate the case when X_D and X_M are correlated. I continue to assume X_W is independent. Technology uncertainty is the primary shift parameter for ex-ante cost that we consider. Of course, this uncertainty is realized ex-post, at which point it loses its salience for ex-post costs.

Two scenarios are discussed below, one where X_D and X_M are compensatory, i.e. negatively correlated, and another where they are complementary, i.e. positively correlated.

Scenario I

Under perfect negative correlation of ex-post shift parameters assumption:

$$\frac{\partial X_M}{\partial X_D} = -1, \frac{\partial X_W}{\partial X_D} = \frac{\partial X_W}{\partial X_M} = \frac{\partial X_W}{\partial X} = 0 \qquad (4\text{-}17)$$

We will consider the extreme case where:

$$X_D = X, \text{ and } X_M = -X \qquad (4\text{-}18)$$

I rewrite the FOC as follows:

$$S^* = S^*(X_D, X_M, X_W, X), \text{ FOC: } \frac{\partial G(S(X_D,X_M,X_W,X),X_D,X_M,X_W,X)}{\partial S} = 0 \qquad (4\text{-}19)$$

Derivative of FOC w.r.t. X:

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X_D}\cdot\frac{\partial X_D}{\partial X} + \frac{\partial S}{\partial X_M}\cdot\frac{\partial X_M}{\partial X} + \frac{\partial S}{\partial X_W}\cdot\frac{\partial X_W}{\partial X} + \frac{\partial S}{\partial X}\right] + \frac{\partial^2 G}{\partial S \partial X_D}\cdot\frac{\partial X_D}{\partial X} + \frac{\partial^2 G}{\partial S \partial X_M}\cdot\frac{\partial X_M}{\partial X} + \frac{\partial^2 G}{\partial S \partial X_W}\cdot \frac{\partial X_W}{\partial X} + \frac{\partial^2 G}{\partial S \partial X} = 0 \qquad (4\text{-}20)$$

From (4-19) we have:

$$\frac{\partial X}{\partial X} = 1 \text{ and } \frac{\partial X_M}{\partial X} = -1 \qquad (4\text{-}21)$$

Based on the independence of parameters assumptions, (4-17), and (4-21) we can summarize (4-20) as follows:

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X_D} - \frac{\partial S}{\partial X_M} + \frac{\partial S}{\partial X}\right] + \frac{\partial^2 G}{\partial S \partial X_D} - \frac{\partial^2 G}{\partial S \partial X_M} + \frac{\partial^2 G}{\partial S \partial X} = 0 \qquad (4\text{-}22)$$

We can further summarize

(4-22) based on (4-18) as follows:

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X}+\frac{\partial S}{\partial X}+\frac{\partial S}{\partial X}\right]+\frac{\partial^2 G}{\partial S\partial X}+\frac{\partial^2 G}{\partial S\partial X}+\frac{\partial^2 G}{\partial S\partial X}=0 \tag{4-23}$$

Therefore, we have:

$$\frac{\partial S}{\partial X}=-\frac{\frac{\partial^2 G}{\partial S\partial X}}{\frac{\partial^2 G}{\partial S^2}} \tag{4-24}$$

At $S=S^*$, $\frac{\partial^2 G}{\partial S^2}>0$, from the assumption of the well behaved objective function; therefore, we can rewrite (4-19) as follows:

$$\left.\frac{\partial S}{\partial X}\right|_{S=S^*}=-\frac{\frac{\partial^2 G}{\partial S\partial X}}{\left|\frac{\partial^2 G}{\partial S^2}\right|}\rightarrow Sign\left(\frac{\partial S^*}{\partial X}\right)=-Sign\left(\frac{\partial^2 G}{\partial S\partial X}\right) \tag{4-25}$$

However, $\frac{\partial^2 G}{\partial S\partial X}=\frac{\partial^2(D+M+W)}{\partial S\partial X}=\frac{\partial^2 D}{\partial S\partial X_D}\cdot\frac{\partial X_D}{\partial X}+\frac{\partial^2 M}{\partial S\partial X_M}\cdot\frac{\partial X_M}{\partial X}+\frac{\partial^2 W}{\partial S\partial X_W}\cdot\frac{\partial X_W}{\partial X}$, following the assumption of the independence of the shift parameters,(4-17), and (4-21) we can summarize:

$$\frac{\partial^2}{\partial S\partial X}=\frac{\partial^2 D}{\partial S\partial X_D}-\frac{\partial^2 M}{\partial S\partial X_M} \tag{4-26}$$

If we consider X a positive shift parameter, from A1 and A2 we can say that $\frac{\partial^2 D}{\partial S\partial X_D}<0$, while $\frac{\partial^2 M}{\partial S\partial X_M}<0$[5]. Therefore, $Sign\left(\frac{\partial^2 G}{\partial S\partial X}\right)$ is negative, hence $Sign\left(\frac{\partial S^*}{\partial X}\right)>$

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[5] Note that if X is positive, then X_M is negative.

0. So, when ex-post shift parameters are negatively correlated, they reinforce each other's effect on S*.

Scenario II

Under perfect positive correlation of ex-post shift parameters assumption:

$$\frac{\partial X_M}{\partial X_D} = 1, \frac{\partial X_W}{\partial X_D} = \frac{\partial X_W}{\partial X_M} = \frac{\partial X_W}{\partial X} = 0 \tag{4-27}$$

I consider the extreme case where

$$X_M = X_D = X \tag{4-28}$$

I rewrite the FOC as follows:

$$S^* = S^*(X_D, X_M, X_W, X), \text{ FOC: } \frac{\partial G(S(X_D,X_M,X_W,X),X_D,X_M,X_W,X)}{\partial S} = 0 \tag{4-29}$$

Derivative of FOC w.r.t. X:

$$\frac{\partial^2}{\partial S^2}\left[\frac{\partial S}{\partial X_D}\cdot\frac{\partial X_D}{\partial X} + \frac{\partial S}{\partial X_M}\cdot\frac{\partial X_M}{\partial X} + \frac{\partial S}{\partial X_W}\cdot\frac{\partial X_W}{\partial X} + \frac{\partial S}{\partial X}\right] + \frac{\partial^2 G}{\partial S \partial X_D}\cdot\frac{\partial X_D}{\partial X} + \frac{\partial^2 G}{\partial S \partial X_M}\cdot\frac{\partial X_M}{\partial X} + \frac{\partial^2 G}{\partial S \partial X_W}\cdot\frac{\partial X_W}{\partial X} + \frac{\partial^2 G}{\partial S \partial X} = 0 \tag{4-30}$$

From (4-28):

$$\frac{\partial X_D}{\partial X} = \frac{\partial X_M}{\partial X} = 1. \tag{4-31}$$

Based on A4, (4-27), and (4-31) I summarize (4-30) as follows

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X_D}+\frac{\partial S}{\partial X_M}+\frac{\partial S}{\partial X}\right]+\frac{\partial^2 G}{\partial S\partial X_D}+\frac{\partial^2 G}{\partial S\partial X_M}+\frac{\partial^2 G}{\partial S\partial X}=0 \tag{4-32}$$

I further summarize (4-32) based on (4-28) as follows:

$$\frac{\partial^2 G}{\partial S^2}\left[\frac{\partial S}{\partial X}+\frac{\partial S}{\partial X}+\frac{\partial S}{\partial X}\right]+\frac{\partial^2 G}{\partial S\partial X}+\frac{\partial^2 G}{\partial S\partial X}+\frac{\partial^2 G}{\partial S\partial X}=0 \tag{4-33}$$

Therefore, we have

$$\frac{\partial S}{\partial X}=-\frac{\frac{\partial^2 G}{\partial S\partial X}}{\frac{\partial^2 G}{\partial S^2}} \tag{4-34}$$

At $S=S^*$, $\frac{\partial^2 G}{\partial S^2}>0$, from A5; therefore, we can rewrite (4-34) as follows:

$$\left.\frac{\partial S}{\partial X}\right|_{S=S^*}=-\frac{\frac{\partial^2 G}{\partial S\partial X}}{\left|\frac{\partial^2 G}{\partial S^2}\right|}\rightarrow Sign\left(\frac{\partial S^*}{\partial X}\right)=-Sign\left(\frac{\partial^2 G}{\partial S\partial X}\right) \tag{4-35}$$

However, $\frac{\partial^2 G}{\partial S\partial X}=\frac{\partial^2(D+M+W)}{\partial S\partial X}=\frac{\partial^2 D}{\partial S\partial X_D}\cdot\frac{\partial X_D}{\partial X}+\frac{\partial^2 M}{\partial S\partial X_M}\cdot\frac{\partial X_M}{\partial X}+\frac{\partial^2 W}{\partial S\partial X_W}\cdot\frac{\partial X_W}{\partial X}$,

following A4, (4-27), and (4-31) we can summarize:

$$\frac{\partial^2 \mathrm{G}}{\partial \mathrm{S}\partial \mathrm{X}}=\frac{\partial^2 \mathrm{D}}{\partial \mathrm{S}\partial \mathrm{X}_\mathrm{D}}+\frac{\partial^2 \mathrm{M}}{\partial \mathrm{S}\partial \mathrm{X}_\mathrm{M}} \tag{4-36}$$

I further summarize

(4-36) based on (4-28) as follows:

$$\frac{\partial^2 \mathrm{G}}{\partial \mathrm{S}\partial \mathrm{X}}=\frac{\partial^2 \mathrm{D}}{\partial \mathrm{S}\partial \mathrm{X}}+\frac{\partial^2 \mathrm{M}}{\partial \mathrm{S}\partial \mathrm{X}} \tag{4-37}$$

From A1 and A2 we can say that $\frac{\partial^2 D}{\partial S \partial X} < 0$, while $\frac{\partial^2 M}{\partial S \partial X} > 0$.

Therefore, $Sign\ \left(\frac{\partial^2 G}{\partial S \partial X}\right)$ is determined empirically based on the effect of X on D versus the effect of X on M. If X is more monitoring centric $\left|\frac{\partial^2 M}{\partial S \partial X}\right|$>$\left|\frac{\partial^2 D}{\partial S \partial X}\right|$, then $Sign\ \left(\frac{\partial^2 G}{\partial S \partial X}\right) > 0$, hence $Sign\left(\frac{\partial S^*}{\partial X}\right) < 0$. If X is more dispute centric $\left|\frac{\partial^2 M}{\partial S \partial X}\right|$<$\left|\frac{\partial^2 D}{\partial S \partial X}\right|$, then $Sign\ \left(\frac{\partial^2 G}{\partial S \partial X}\right) < 0$, hence $Sign\left(\frac{\partial S^*}{\partial X}\right) > 0$.

Theoretical Propositions for Contract Deviations

Now, under full and complete information, correct optimizers would be expected to choose the optimal S^* that minimizes the total governance cost G. However, parties to a transaction can end up at a product performance contract specificity $S \neq S^*$, for any set of reasons, ranging from calculation mistakes to not having access to relevant information. Thus empirically we might observe deviations from the optimal: $\Delta S^*=S-S^*>0$ for over-specified and $\Delta S^*=S-S^*<0$ for under-specified contracts. What are the impacts of such deviations?

First, S^* being the optimal of the cost minimizing calculus, the total governance cost is higher for any $S \neq S^*$, i.e. $G(S) > G(S^*)$. Next, we can decompose the impact of the deviations on the individual transaction costs. In particular, with $\partial D/\partial S < 0$, under-specified contracts incur higher dispute costs compared to over-specified ones. Similarly, with $\partial M/\partial S > 0$, under-specified contracts incur lower monitoring costs compared to over-specified ones. Lastly, with $\partial W / \partial S > 0$, under-specified contracts also incur lower monitoring costs compared to over-specified ones.

Proposition 4a: $G(S) > G(S^*)$ for all $|\Delta S^*| = |S - S^*| > 0$. Total governance costs are higher for all over- or under-specified contracts.

Proposition 4b: $D(S{:}\Delta S^* = S - S^* < 0) > D(S{:}\Delta S^* = S - S^* > 0)$. Ex-post Dispute costs are higher for under-specified contracts relative to over- specified contracts.

Proposition 4c: $M(S{:}\Delta S^* = S - S^* < 0) < M(S{:}\Delta S^* = S - S^* > 0)$. Ex-post Monitoring costs are lower for under-specified contracts relative to over-specified contracts.

Proposition 4d: $W(S{:}\Delta S^* = S - S^* < 0) < W(S{:}\Delta S^* = S - S^* > 0)$. Ex-ante Contract Writing costs are lower for under-specified contracts relative to over-specified contracts.

Hypotheses

Transaction cost economics suggests that parties to an exchange seek to safeguard their specific investments. The notion of safeguarding is more prevalent when the uncertainty is higher or a firm has to engage in multiple transactions. Market structures offer the least amount of the safeguards, while hierarchical structures, such as vertical integration, offer the highest level of the safeguards. In the hybrid structures however, firms seek to safeguard their specific investments by choosing contractual governance safeguards (Mooi & Ghosh, 2010).

Figure 4-2 illustrates the role of different independent exogenous factors on the choice of product performance contract specificity and subsequently on the contractual transaction costs. I propose this framework based on the predictions of the TCE in the context of manufacturer supplier relationships. On the left-hand side of this figure the main TCE variables, i.e. asset specificity, uncertainty, and frequency are presented. As it is evident, I operationalize asset specificity with OEM transaction specific investments, OEM TSI, and uncertainty with technological uncertainty, modularity and mixing-and-matching. I am also controlling for frequency. As another antecedent of product performance contract specificity, I am considering monitoring technology. I treat this variable as an endogenous variable. One can argue that monitoring technology is a technology choice by the OEM. In the literature, measurement ambiguity of the product is an antecedent of product performance contract specificity (Mooi & Ghosh, 2010). However, I have added monitoring capability, or monitoring technology, in the model. Higher level of monitoring technology leads to lower level of measurement ambiguity.

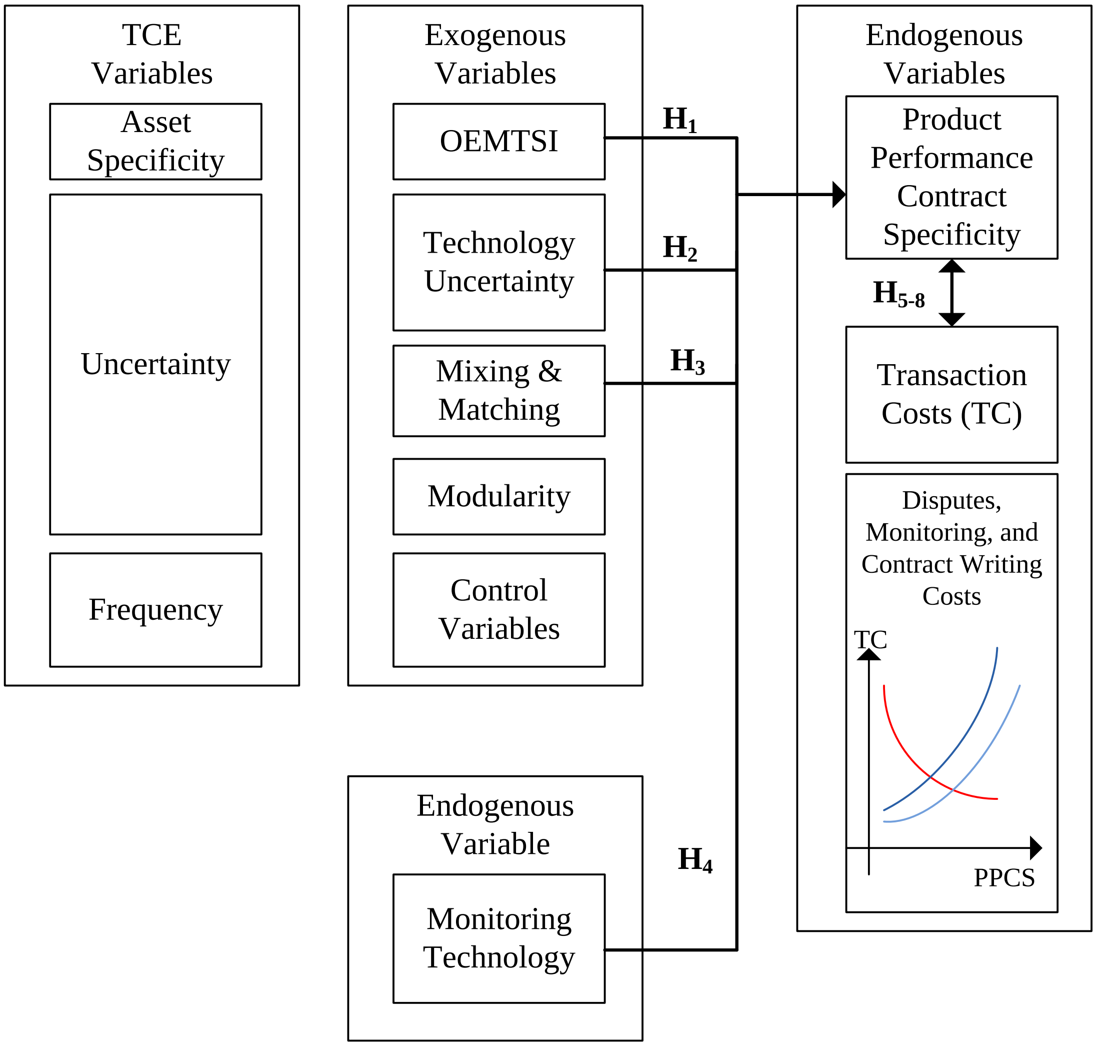

Figure 4-2. Schematic Diagram of Influencing Factors over the Choice of Product Performance Contract Specificity

<u>Safeguarding OEM's Transaction Specific Investments</u>

Many transactions between OEM and vendors in our MCS context are characterized by specific investments made by the OEM to enhance the productive value of the relationship. For example, in many industries, interconnect standards are not very well developed, often leaving it up to the OEMs to find out ways to best integrate a vendor's components and technology. Some vendors supply to multiple industries and develop proprietary interfaces requiring the OEM to develop particular technological protocols that cannot be easily redeployed to other business relationships. Technological innovations at the vendor end often force OEMs to adopt protocols that are not widely adopted in the industry. Under these circumstances, OEMs become vulnerable to opportunistic renegotiations from the vendor. In other words such transaction specific investments made by the OEM (OEMTSI) raise their cost of disputes significantly, calling for appropriate safeguards (Mooi & Ghosh, 2010). In our context, greater specificity of the contracts can provide such safeguards by identifying a greater number of contingencies (Crocker & Reynolds, 1993; Ghosh & John, 2009). To relate to the model, OEMTSI acts as a dispute cost (D) shifter, X_D with $\partial S^*/\partial X_D > 0$ as per Proposition 1. Hence,

> H_1 - Ceteris Paribus, product performance contract specificity is positively associated with the OEM`s Transaction Specific Investments.

Technological Uncertainty

Uncertainty associated with pace of technological changes is a factor that is secular to almost all industrial transactions. Technological uncertainty increases the cost of writing ex-ante contractual clauses because parties have to protect against the unforeseen contingencies of obsolescence, losing competitiveness and maintaining productive value of their investments (Ghosh et al., 2006; Stremersch et al., 2003; Wilson et al., 1990). However, this assumes an even bigger role for OEM transactions in MCS contexts. In some cases, lacking appropriate industry standards, vendors adopt varying technology protocols. While the OEM in this situation carries the onus of managing the different interconnect challenges, they also bear the brunt when these different protocols incorporate higher levels of technological uncertainties, compounding the interconnect challenges. Not only are there more contingencies to anticipate, but for those that have been anticipated, there is a higher likelihood of a mismatch between the outcome and the suggested call to action. This further increases the ex-ante costs of writing a contract with all appropriate contingencies and call to actions specified. Bounded rationality highlights the challenge even more as cognitive limits are reached and economic agents increasingly struggle to identify the appropriate marginal clause. To relate to the model, technological uncertainty acts as an ex-ante cost (W) shifter, X_W with $\partial S^*/\partial X_W < 0$ as per Proposition 3. Hence,

> H_2 - Ceteris Paribus, the higher the technological uncertainty of a specific transaction, the lower the product performance contract specificity.

Modularity

One of the most significant characteristics of multi-component systems is the degree to which its components are separable. Modular systems are characterized by clearer interconnect boundaries of components (Matutes & Regibeau, 1988; Venkatesh & Kamakura, 2003). On the other end, less modular, i.e. more integrated systems, make it difficult to clearly identify the interconnect boundaries. While higher degree of modularity can reduce dispute costs by making it easier for the OEM to isolate the causes and sources of the product failure, it can also reduce potential monitoring costs by making it easier to monitor individual component performances with lesser interconnect confounds. While one effect (lower dispute costs) supports lower degree of specificity as per Proposition 1, the other (lower monitoring costs) supports higher degree of specificity as per Proposition 2. Thus the actual outcome is contextual, depending on whether the impact is more on dispute or on monitoring. So, we identify modularity as a key consideration but do not offer an explicit hypothesis, treating the impact as an empirical matter.

Mixing and Matching

An enduring characteristic of MCS markets is mixing and matching of components from different suppliers. When the suppliers are "single line" suppliers, i.e. they specialize in only one component; the OEM has to combine its component with other suppliers'. When the suppliers are "full line" they carry all components that the OEM requires, and the OEM has a choice to either source all components from the single supplier or "mix and match" some of its components with other suppliers'. However, most suppliers are "short line," i.e. they carry more than one but not the whole range of components. As in the full line case, the OEMs retain the flexibility to mix and match some of their components with others. The OEM incentives to do this could be both functional as well as strategic. On the strategic side, some of the mix and match can allow the OEM to achieve market growth by plugging gaps in customer preferences (Ray et al., 2016). At the same time, mix and match could also help the OEM leverage their dependence on suppliers and act as a ploy to extract privileges (Ray et al., 2016). Not surprisingly, many suppliers attempt to protect their revenue stream by imposing direct and indirect constraints on the OEM's mix and match activity. These constraints can come in various forms, including contractual restrictions and warranty denials. While these constraints might restrict the OEM from freely implementing its component choices, they also come with the potential to create major interconnect problems. As more different suppliers' components are mixed and matched, the OEM faces an increasing array of performance related disputes in the event of a performance failure. This is not only due to the multiplicity of suppliers but also due to a broader spectrum of possible interconnect failures as each supplier refuses to stand behind the interconnect performance of another supplier's component. This increases the potential dispute costs, leading to a secular incentive to increase contractual specificity to bring it down. To relate to our model, unconstrained mix and match acts as an ex-post dispute cost (D) shifter, X_D with $\partial S^*/\partial X_D > 0$ as per Proposition 1. Hence,

> H_3 - Ceteris Paribus, product performance contract specificity is positively associated with the degree to which inter-brand mixing and matching of components is unconstrained.

<u>Monitoring Technology</u>

The ability to conduct ex-post monitoring is at the heart of the TCE predictions regarding governance forms. Transactional contexts that increase monitoring costs tend to be internalized in hierarchical structures while arms length structures are favored when monitoring costs are lower (Ghosh & John, 1999). In our MCS context, the emerging *Internet of Things* (IoT) technologies have brought significant component performance and usage monitoring capabilities within the reach of erstwhile traditional OEM channels. There are various such technologies - some affording real-time data trends over the internet while others depending on periodic local data dumps. Either way, these technologies are at the heart of the so-called *industrial big data infrastructure*. Investments in such technologies are a strategic decision and mostly involve installing sensors and actuators on different components of a system to measure *both* engineering performance parameters (temperature, pressure, cycle times, etc.) as well as usage (service intervals, in some cases even chemical composition of additives). The major upshot of such investments is a reduction in monitoring costs as it is now far easier to collect the data that can now be used to create a performance and service map to pinpoint sources of product failure and assign responsibilities. Such abilities support greater contractual specificity identifying different performance and usage parameters as part of the bilateral agreements - and which can now be economically monitored. To relate to our model, the IoT based monitoring technology acts as a *negative* ex-post monitoring cost (M) shifter, ($-X_M$) with $\partial S^*/\partial X_M < 0$ as per Proposition 2. Hence,

H_4 - Ceteris Paribus, product performance contract specificity is positively associated with monitoring technology.

Table 4-2 summarize the list of independent variables, and their effect on product performance contract specificity.

Table 4-2. List of Variables and Hypothesized Effect on Product Performance Contract Specificity (PPCSpec)

TCE Variables			**Variables**	**Hypotheses**	**Effect on** PPCSpec
Asset specificity		Independent Variables	OEM's Transaction Specific Investments	H_1	+
Uncertainty			Product Architecture: (Modularity)		
	Environmental		Technological Uncertainty	H_2	-
			Mixing and Matching	H_3	+
			Product/Component Monitoring Technology	H_4	+
	Behavioural	Control	Tenure of the relationship		
Frequency			Frequency of Transaction		
			Frequency of Financial Transactions		
			Perceived Importance of the component		
			Component to Product Price Ratio		
			Scope of Transaction		
			Transaction Size		
			Supplier's Technology (proprietary/standard)		
			Number of Key Components		
			OEM Size		
			Supplier Size		

The Impact of Deviation from Optimal Contracting on Transaction Costs

The managerial interest in specifying contractual clauses that we speak to center around the assumption that appropriately specified contracts minimize transaction costs.

This imposes a burden of non-optimality. In many cases, firms may not have all the information, or even might make mistakes in its assessments. In other words, the contractual specificity chosen might deviate from the optimal one. What is the marginal impact of deviating from such optimal contracting? The governance literature is generally thin in terms of estimations of transaction costs - especially impact of deviations from the estimated optimal (Mooi and Ghosh, 2010 being a notable exception). In our case, the testable hypotheses follow directly from Propositions 4a-d. On the other hand, under-specified contracts do not cost as much to write and monitor as the optimally specified contracts. However, by signing such under-specified contracts, the buyer is exposed to higher potential disputation costs. So, one may suggest:

H_5 - Total governance costs are higher for both over and underspecified contracts.

H_6 – OEMs who choose to offer under-specified (over-specified) contracts to their suppliers face higher (lower) ex-post disputation cost.

H_7 – OEMs who choose to offer over-specified (under-specified) contracts to their suppliers face higher (lower) ex-post monitoring cost.

H_8 – OEMs who choose to offer over-specified (under-specified) contracts to their suppliers face higher (lower) ex-ante writing cost.

Impact of Disputes on Product Performance

In the context of multi-component systems, where an OEM purchases various components from different suppliers, the final product's performance is a function of component performance. When an OEM signs a contract with a supplier, the OEM faces two major ex-post costs. First, a monitoring cost which is the cost to monitor supplier's conformity to the contracts requirements. Second, a dispute cost which is the cost of disputing with the supplier over any deviation from initial expectations. In an effort to facilitate supplier monitoring, or to limit the monitoring cost, the OEM may resort to product monitoring technologies, which help OEM gather vital product level performance data. Such data is eventually useful to locate the source of failure if any, or monitor the conformance of the suppliers to their contracts. Moreover, to limit the level of disputes, the OEM may try to write well specified contracts to cap the ex-post contract disputes. A dispute can happen either because the OEM's expectations are not clearly communicated with the supplier through the contract, i.e. suboptimal contract, or because the supplier is shirking responsibility. Either of these scenarios may spark ex-post disputes. We now examine the role of dispute cost on OEM's product enhancement efforts.

Governance Value Analysis proposes that the firm level performance is an outcome of governance attributes, strategy, and resources (Dahlquist & Griffith, 2014; Ghosh et al., 2006; Ghosh & John, 2009; Nickerson et al., 2001; Poppo & Zhou, 2014; Ruester & Neumann, 2009; Wernerfelt, 2005). A key product's performance can affect the firm-level performance. In this section, I study the direct and indirect impact of governance attributes on product enhancement outcomes, while controlling for the role of business strategy and firm resources. Empirically, I have selected product enhancement outputs as the proxy for product performance.

A large of body of literature is investigating the direct role of governance in interfirm relationships (Ferguson et al., 2005; Poppo & Zhou, 2014). Also, there is a growing literature on the governance and performance link. Performance is measured using different variables: exchange performance (Cannon et al., 2000), exchange relationship (Mooi & Gilliland, 2013; Poppo & Zenger, 2002; Susarla et al., 2009), exchange satisfaction (Jap & Ganesan, 2000; Poppo & Zenger, 2002), relationship satisfaction (Mesquita & Brush, 2008), production efficiency (Hoetker & Mellewigt, 2009), alliance performance (Ghosh & John, 2005; Sande & Haugland, 2015), and product enhancement and cost reduction (Mooi & Gilliland, 2013; Sande & Haugland, 2015). There is also a small literature around the impact of deviations from optimal contracting on performance (Duarte & Davies, 2003; Menon et al., 1996). Transaction costs are the inevitable outcome of any governance form, whether optimal or suboptimal. More importantly, the impact of disputes on firm performance cannot be identified intuitively. That is partially because of the trade-off between the disputes and monitoring costs with respect to the product contract specificity, and partially because of the situation where dispute costs tend to be high or low, e.g. in the case of disputes when there is a major component failure versus disputes when there is no component failure between the OEM and the component suppliers. In the MCS context, the firm performance is appropriately proxied with product or system performance because business transactions related to these product systems are defining elements of firm performance.

A focus on transaction cost minimization, while ignoring the potential positive impact of such transaction cost on product performance, can compromise opportunities to enhance value for the OEM. There is a trend in marketing literature that looks at the role of conflict as both functional and dysfunctional (Crocker & Reynolds, 1993; Wuyts & Geyskens, 2005). In this study of MCS, I investigate the functional and dysfunctional role of transaction costs, i.e. disputes, in the industrial buyer and seller relationship. I consider dysfunctional disputes as the cost that does enhance value (Crocker & Reynolds, 1993). In this view, I consider disputes as deadweight losses. Alternatively, I consider functional disputes as performance improvement mechanisms. This is to identify under what circumstances the transaction cost minimization efforts are helping or limiting OEM's value enhancement efforts. When cost minimization efforts facilitate value enhancement efforts the OEM enjoys a higher performance. This is because the cost savings are added to the value created. When these cost minimization efforts impede the value enhancement efforts the savings from transaction cost minimization are compromised as the created value declines.

Empirically, I collect data from industrial buyers, OEMs, who are dealing with different key component suppliers. In the survey design, I ask for a supplier with whom the OEM has experienced a major component failure and another supplier with whom the OEM has experienced a minor component failure if any. This set up not only makes it possible to control for OEM specific effects, but also makes it possible to investigate whether disputes during a major component failure can act as functional disputes, and disputes during a minor component failure (if any) can act as dysfunctional ones. I find empirical support for both functional and dysfunctional explanations.

Evidently, there is an apparent gap in the literature to investigate the indirect impact of governance form in the form of transaction costs on performance. To the best of my knowledge, no paper has studied the role of transaction costs on performance before.

Disputes as Deadweight Losses

One way to treat any dispute cost between the industrial partners is to consider it as its literal concept as cost (Mooi & Ghosh, 2010). In this view, any dispute between the buyer and the seller is considered as friction which wastes resources on both sides. Such disputes can spark ex-post as a result of the inappropriate contracting (Anderson & Dekker, 2005), not clarifying the expected performance details, transaction problems (Gooner et al., 2011; Wuyts & Geyskens, 2005), or a shirking supplier from a commonly understood grounds (Heide & John, 1990). When the buyer and the seller are engaged in frequent purchases, and there is no major component failure in the OEM's final product such disputes tend to be abrasive, eroding the OEM's resources, which could be deployed more purposefully somewhere else in the organization otherwise, resources such as time and organizational problem solving capability. In a dynamic market setting, such resources are necessary to keep the product abreast the competition.

> H_9 - Ceteris Paribus, ex-post disputes with a supplier are negatively associated with OEM's product enhancement outcomes, when there is no major component failure incident with the supplier.

Disputes as Performance Improvement Mechanisms

Alternatively, one can argue that when the buyer and the seller experience a major component ex-post failure, both parties can potentially engage in ex-post disputes. A major component failure can happen when there is a significant misalignment, between the buyer and the seller, in the governance tool design or in the compliance of the supplier to the desired expectations of the OEM, or both. As a result, such disputes may take on a corrective role, as renegotiation or joint action (Mesquita & Brush, 2008). Several possibilities exist vis-à-vis these ex-post disputes. The OEM can clarify the performance expectations to eliminate the root of such failures (Celly & Frazier, 1996; Grover & Malhotra, 2003). The OEM and the supplier can jointly work on a superior design which prevents such failures in future. Or, the OEM can align the supplier's behavior to comply with the OEM's standards (Celly & Frazier, 1996; Grover & Malhotra, 2003). In any case, the impact of such disputes on product performance can potentially be positive. Such disputes, or renegotiations, engage significant resources in both OEM and supplier companies to resolve the faulty issue. As a result, we may witness higher product enhancement outcomes, when both parties engage in disputes after a major component failure.

H_{10} - Ceteris Paribus, ex-post disputes with a supplier are positively associated with OEM's product enhancement outcomes, when there is a major component failure incident with the supplier.

Figure 4-3 illustrates the influencing factors on product performance. The variable to measure the product performance is product enhancement outcomes.

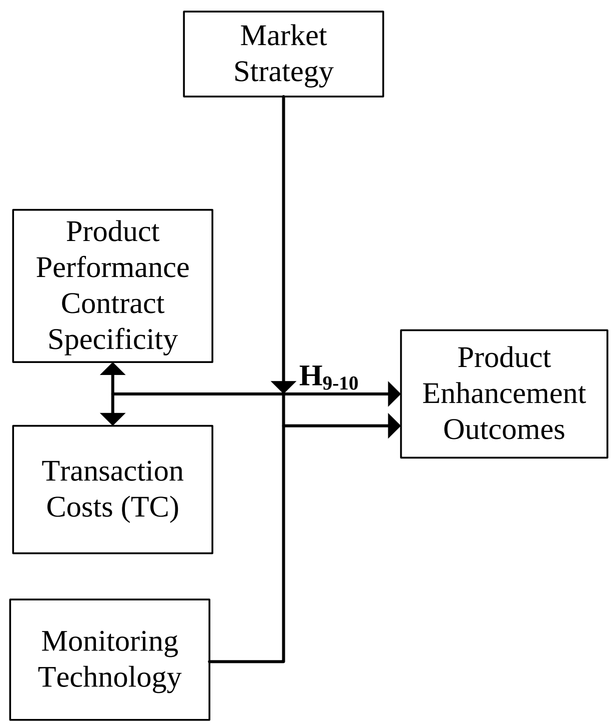

Figure 4-3. Influencing Factors on Product Enhancement Outcomes

Chapter Five Data

In this research, industrial manufacturers which are active in procuring components, assembling components, and selling completed product to the market are of our interest. The unit of analysis in this research is the relationship of a buyer and one its component suppliers. An online survey has been designed from scratch in Limesurvey software to collect information from the industrial buyers about their procurement experience with two of their component suppliers. Limesurvey is open source software to design online surveys. The Limesurvey software and the completed answers are both stored locally on McMaster's server. I have recruited a professional marketing research firm[6] to invite industry experts to fill out our survey. During several communications with the marketing research firm, I clearly specified the profile of manufacturing companies and experts working in such companies that are of our interest. However, I have placed several questions in the survey to screen out nonconforming respondents. This includes a series of standard questions to make sure the invitee is at legal age and working full time. Moreover, I included questions to make sure the invitee comes from a manufacturing company that assembles component to manufacture a final product and sells the final product to another entity. The latter is specifically important

[6] Research Now Company, Toronto Branch.

because manufacturing companies who use the final product themselves may have different set of constraints with respect to quality and price when dealing with their supplier. For example, a mining company which is self-assembling the required machinery to extract raw materials is the final user of the machinery as well. Since there are no intended customers for the manufactured, i.e. assembled, machinery in this case, the mining company is not faced with any <u>direct</u> constraints imposed from the market for the functionality of the machinery. Overall, I believe such a difference in the business model may impose critical contextual conditions, so I have limited the scope of the research to the companies which are manufacturer of an assembled product with an ultimate end of selling the final product in the market. Other than this specification, I have imposed no further constraint in our choice of companies and industries.

In addition to the above mentioned screening stages, I placed a page with some illustrative figures in the survey, i.e. Figure 5-1 and Figure 5-2, asking the respondents to choose two suppliers. One a supplier which they had experienced a case of major component failure in the past one year, and another a supplier which they had experienced a case of minor component failure if any in the same time period. Then, I asked them two provide the names of the components, a short description and the price ratio of the component and the final product. The majority of respondents who left the survey had done so in one the stages of abovementioned screening steps. Those who passed these steps completed the survey to the end.

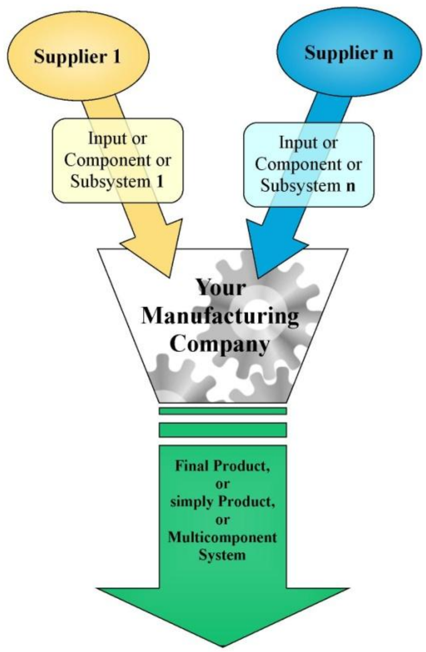

Figure 5-1. Schematic Relationship between an OEM and its suppliers

By asking the respondents to identify two suppliers, I will be able to control for OEM specific effects that are not necessarily observable or measured. (Ghosh et al., 2006) use a similar sampling of two data point per firm to account for firm specific effects in their survey. Moreover, I will be able to enforce some variation in responses which enables me to test the indirect effect of ex-post disputes on product enhancement outcome hypotheses.

For quality assurance purposes, I also blended in two questions in the two different spots in the survey to test the attention of the respondents, where such questions were least expected. In these questions, I simply asked the respondents to choose a given choice. Those responses with both questions wrong were rejected and were not counted in the final completed surveys.

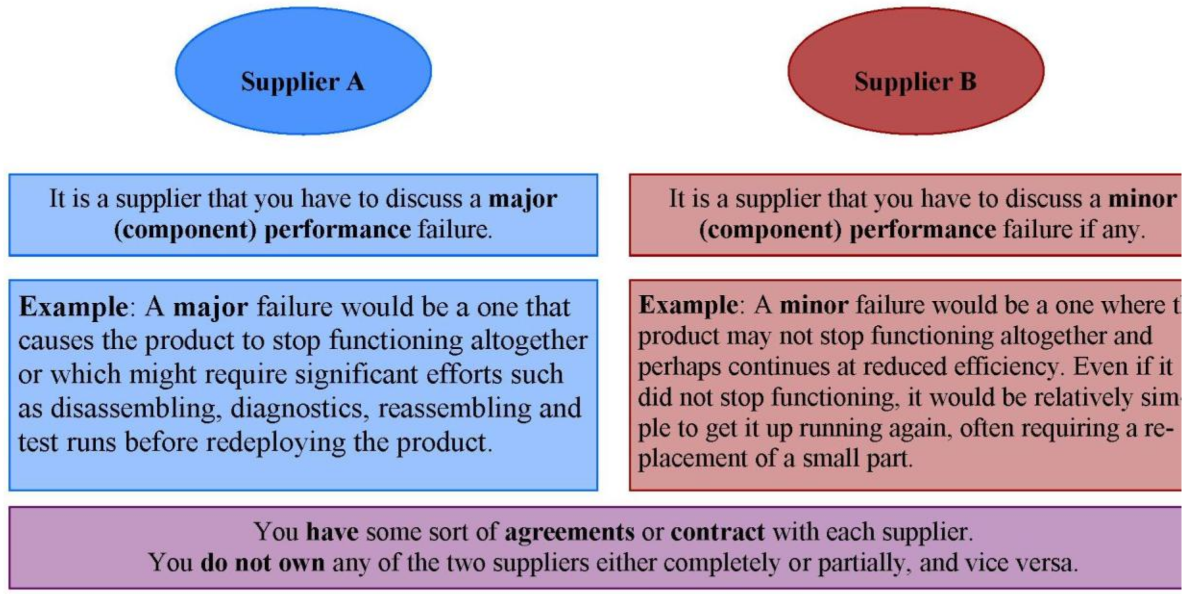

Figure 5-2. The choice of two different suppliers

In this chapter, I will first present the sample descriptive. Then, I move on to the measurement section, presenting key variables and control variables used in this study.

Sample Descriptive

The professionals whom I have surveyed come from a variety of industries. Overall, a total of 1205 professionals attempted the survey. The questionnaire screened these initial attempts by the respondents, based on predetermined criteria, to finally qualify 476. Of these, I received a total of 263 responses (a 55% response rate). I rejected marked 63 responses based on attention screening criteria. In sum, 200 respondents from manufacturing companies from a wide selection of industries have completed the survey (net 42% response rate). Table 5-1 lists the industries surveyed. As it is evident, four industries have the highest frequency amongst the others. They are industrial manufacturing, transportation equipments, i.e. automotive industry and system manufacturers, controlling instruments and medical devices, and finally, electronic devices from the highest to lower sampling frequency. Overall, the diversity of industries in the sample will increase the generalization of the empirical results.

Respondents have answered questions about a product of their choice, two key components of that product, suppliers of those key components, their market, and their own company. I have asked them questions about the product, component technology, contractual terms, ex-ante and ex-post contracting efforts, performance outcomes, and their menu of product warranties.

The mean value of the completion time is 45 minutes with a median of 36 minutes, among all 200 respondents. The questionnaire preparation, pre-tests, coding for the server etc. took several months of work. The data collection itself took seven weeks to complete.

Table 5-1. Industries Sampled

Two Digit SIC Code	Industry	Frequency	Percentage
16	Heavy Construction	1	0.5%
17	Construction	2	1.0%
20	Manufacturing – Food products	2	1.0%
22	Manufacturing – Textile Products	2	1.0%
25	Manufacturing – Furniture and Fixtures	7	3.5%
26	Manufacturing – Paper and Allied Products	1	0.5%
28	Manufacturing – Chemicals and Allied Products	4	2.0%
29	Manufacturing – Petroleum Refining and Related Industries	2	1.0%
30	Manufacturing – Rubber and Miscellaneous Plastics Products	8	4.0%
32	Manufacturing – Stone, Clay, Glass, and Concrete Products	1	0.5%
33	Manufacturing – Primary Metal Industries	2	1.0%
34	Manufacturing – Fabricated Metal Products	8	4.0%
35	Manufacturing – Industrial and Commercial Machinery and Computer Equipment	56	28.0%
36	Manufacturing – Electronic and Other Electrical Equipment and Components	17	8.5%
37	Manufacturing- Transportation Equipments	39	19.5%
38	Manufacturing - Measuring, Analyzing, and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks	23	11.5%
39	Miscellaneous Manufacturing Industries	7	3.5%
47	Transportation Services	2	1.0%
50	Wholesale Trade-Durable Goods	4	2.0%
52	Building Materials, Hardware, Garden Supply, and Mobile Home Dealers	1	0.5%
73	Business Services	1	0.5%
Not Reported		10	5.0%
Total		**200**	**100.0%**

Respondents Characteristics

Designations

The list of respondents' designations is summarized in Table 5-2. Most of the respondents hold managerial positions, which reassures their ability to address the questions asked in the survey.

Table 5-2. List of Respondents' Designations and Frequencies

Designation	**Frequency**
President /Owner	23
VP	16
C-Level Manager	15
Director	21
Manager	93
Senior Expert	11
Other	20
Total	**199**

Experience

Average experience in the current position: 13 years and 4 months. Evidently, this number of years of experience in industrial settings reassures the respondents' ability to answer the questions with a good knowledge of the company and product at hand.

Roles

The respondents have identified themselves to be working in following areas. The number of observations is 200 in total. Respondents could choose as many roles as applicable to their job description. Table 5-3 summarizes the frequencies of each managerial role among those who took the survey. As it is evident, all respondents have a related role in the context of relationships with component suppliers.

Table 5-3. Roles of the Respondents and Frequencies

Engineering – Design	77
Engineering - Manufacturing	82
Supply Chain Management	97
Supplier Contract Administration	77
Component Procurement	99
Supplier Contract Performance Monitoring	73
Inbound Logistics	66
Inventory Management	93
Other	20

Firm Size

Respondents have mentioned their company size, the annual revenue, in million dollars. The average OEM size is 5.2 Billion Dollars. However, the median size is 47.5 Million Dollars. The sample is positively skewed because of five extreme company size values, ranging from 30 to 250 Billion USD. Table 5-4 provides further details on the size of the companies who participated in the study. The breadth of OEM size reassures that wide samples of firms have been surveyed.

Table 5-4. OEM Size as reported by the Respondents (in Million USD)

	Obs	Mean	Std. Dev.	Min	Max
OEM SIZE	200	5250.683	26299.87	.1	250,000

Respondent's Knowledge and Involvement

The respondents have also rated their involvement and knowledge of their business on a seven point Likert scale. Table 5-5 summarizes the mean of respondents' knowledge and involvements. On average, the respondents have been fairly knowledgeable 5.6, and involved 5.8 with 7 being the highest mark. The mean values indicate that respondents are knowledgeable about the area of the relationship with suppliers.

Table 5-5. Knowledge and Involvement of the Respondents about the Business Practices

	Obs	Mean	Std. Dev.	Min	Max
I am actively involved in dealing with some of our component suppliers.	200	5.665	1.595	1	7
I am knowledgeable about my company's/SBU's practices in dealing with some of our component suppliers.	200	5.805	1.290	1	7

Measurement Reliability and Validity

In this section, I will first review the key variables, the control variables, and instrumental variables which have been used in the empirical validation of the hypotheses. Next, I move on to explaining the efforts taken to insure the reliability and validity of the measurements.

Dependant Variables

Table 5-6 illustrates the list of the key dependant variables. Those are product performance contract specificity, different transaction costs, monitoring technology, and product enhancement outcomes. I measure these using questions with a seven-point Likert scale. There are three different transaction costs. They are contract writing cost, contract monitoring, and contract disputation. I have measured each transaction cost separately and objectively in the terms of the man-days spent by company's professional to accomplish. Table 5-6 also represents the range of these dependent variables. I have used the natural logarithm transformation of the transaction costs, given the wide range of responses.

Considering that in many cases, the reported disputes are zero, I have also used Log(Number of Man-day +1) transformation. This way, I have made sure that I do not lose any data points, as a simple logarithm transformation of zero will be treated as a missing data. Shifting of data by one unit and then performing logarithm transformation transforms zero to zero. Given the open range of the measurement of the transaction costs, this should cause no serious data distortion. I also mean center data, as another transformation technique. All results are reported in Chapter Seven.

Moreover, note that while MT is not a dependent variable in this study, it is treated as an endogenous variable

Table 5-6. Variable Descriptive

Construct	**Variable**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Measurement**	**α**
Product Performance Contract Specificity	$PPCSpec_{ij}$	400	4.927	1.279	1	7	5-items scale	0.829
Contract Disputation	$LogD_{ij} + 1$	400	1.265	1.284	0	6.216		
Cost	$LogD_{ij}$	304	1.251	1.522	-2.302	6.214	No. of man-	n/a

Construct	Variable	Obs	Mean	Std. Dev.	Min	Max	Measurement	α
Contract Monitoring Cost	$LogM_{ij} + 1$	398	1.257	0.893	0.182	5.198	days	
	$LogM_{ij}$	398	0.766	1.142	-1.609	5.193		
Contract Writing Cost	$LogW_{ij} + 1$	400	1.711	1.159	0.095	5.303		
	$LogW_{ij}$	400	1.300	1.497	-2.302	5.298		
Total Governance Cost	$LogG_{ij}$[7]	398	2.287	1.402	-0.431	6.500		
Extent of Monitoring Technology	MT_i	200	3.403	1.802	1	7	8-items scale	0.949
Product Enhancement Outcomes	PE_Out_i	200	5.497	0.912	2.286	7	7-items scale	0.870
OEM's Transaction Specific Investments	$OEMTSI_{ij}$	400	3.699	1.400	1	7	6-items scale	0.834
Technology Uncertainty	$TECUNC_i$	400	2.443	1.079	1	6	3-items scale	0.632
Modularity	MOD_i	200	3.616	1.326	1	7	3-items scale	0.560
Mixing and Matching	MXM_{ij}[8]	400	0.478	0.500	0	1	Dummy Var.	n/a
Low-Cost Strategy	LC_i	200	3.820	1.716	1	7	1-item scale	n/a
Differentiation Strategy	$DIFF_i$	200	5.475	1.077	2.667	7	3-items scale	0.653
OEM Integrative Resources	$INTRES_i$	200	5.146	1.288	1	7	5-items scale	0.870
Number of Key Components	$NKEYCOM_i$✧	153	12.902	15.242	2	78	Grounded No.	n/a
Number of Potential Key Suppliers	$NPOTSUP_{ij}$✧	357	5.367	4.459	1	20	Grounded No.	n/a
Proprietary Technology of the Supplier	$SUPTEC_{ij}$	400	3.809	1.963	1	7	2-items scale	0.871
Supplier's Transaction Specific Investments	$SUPTSI_{ij}$	400	3.730	1.644	1	7	5-items scale	0.907
Tenure of the Relationship	$TENURE_{ij}$✧	385	12.597	8.418	1	40	Years	n/a
Scope of the contract	$TRANSCOPE_{ij}$	400	3.045	1.893	1	10	Formative Scale	n/a

[7] LogG=Log(D+M+W)

[8] 1 if there is no constraints, 0 if there is a constraint. Out of the 400 observations 209 are 0, and 191 are 1.

✧ Descriptive reported after excluding outliers.

Construct	Variable	Obs	Mean	Std. Dev.	Min	Max	Measurement	α
Component to Product Price Ratio	$COMRAT_{ij}^{✧}$	344	0.152	0.151	1.00E-06	.55	Grounded No.	n/a
OEM Size	$OEMSIZE_{i}^{✧}$	163	113.75	227.257	0.1	1200	Million Dollars	n/a
Supplier Size	$SUPSIZE_{ij}^{✧}$	324	49.991	81.850	0.1	400		n/a
Transaction Frequency	$TRANFREQ_{ij}$	400	4.805	1.441	1	7	1-item scale	n/a
Financial Transaction Frequency	$FINFREQ_{ij}^{✧}$	352	13.568	11.029	0	50	Grounded No.	n/a
Component Importance	$COMIMP_{ij}$	400	5.935	1.281	1	7	2-items scale	0.615
Product Importance	$PROIMP_{i}$	200	6.31	1.291	1	7	1-item scale	n/a
Unpredictability of Innovation	$UNPINN_{i}$	200	4.48	1.478	1	7	1-item scale	n/a
Customer Heterogeneity	HET_{i}	200	5.268	1.053	2	7	3-items scale	0.742

Measurement Reliability

To assess the measurement reliability for multi-item variables I used Cronbach's alpha method. The results are presented in Table 5-6. Except two of the measures, i.e. modularity and technology uncertainty, which are marginally acceptable, the rest are acceptable. Modularity measurement is adapted from (Ghosh & John, 2009), I drop one measurement item to improve reliability and validity of the scale. Significance of the results does not change after dropping this item. Technology uncertainty measurement with three items is adopted from (Fornell & Larcker, 1981), no item is dropped.

Measurement Validity

To test unidimensionality and discriminant validity of the variables I perform an exploratory factor analysis. First, I include items from the following 11 composite variables: PPCSpec, MT, PE_Out, OEMTSI, TECUNC, MOD, DIFF, INTRES, SUPTEC, SUPTSI, and COMIMP. I find 11 factors with Eigen values greater than one, after rotating the factors using principal component analysis. I estimate a measurement model with 11 factors. Each factor represents one of the composite variables mentioned before. The calculated goodness of fit indicators suggests a fair fit, e.g. root mean squared error of approximation (RMSEA)=0.080 and comparative fit index (CFI)=0.788. Moreover, all of the factor loading are significant at p=0.001, which supports the convergent validity. Also, I calculate the average variance extracted (AVE) of the item loadings for each composite variable and squared correlations (SC) of the factors based on the method suggested by (Podsakoff & Organ, 1986). Based on their method convergent validity is achieved once AVE of each composite variable is capable of explaining 50% of the variance of that variable, or in other words they are larger than 0.5. All composite variables have AVE larger than 0.5 in Table 5-7.

Discriminant validity is achieved when AVE is larger than the squared correlation of the factor with any other factors in the model. In other words, discriminant validity is achieved when each latent variable shares more variance with its indicators than any other latent variable which in turn are expressed by a different set of indicators. Table 5-7 shows clearly that each AVE is larger than any SC; therefore, discriminant validity is supported. However, squared correlation of SUPTSI and OEMTSI is marginally larger than OEMTSI's AVE.

Table 5-7. Convergent and Discriminant Validity Assessment

Squared Correlation between the Factors and AVE*

		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
F1.	PPCSpec	**0.830**										
F2.	MT	0.139	**0.757**									
F3.	PE_Out	0.135	0.092	**0.705**								
F4.	OEMTSI	0.398	0.137	0.121	**0.556**							
F5.	TECUNC	0.089	0.004	0.026	0.028	**0.526**						
F6.	MOD**	0.043	0.017	0.031	0.057	0.001	**0.611**					
F7.	DIFF	0.060	0.023	0.473	0.035	0.001	0.027	**0.735**				
F8.	INTRES	0.242	0.163	0.334	0.188	0.060	0.019	0.236	**0.807**			
F9.	SUPTEC	0.127	0.027	0.062	0.196	0.000	0.042	0.045	0.039	**0.910**		
F10.	SUPTSI	0.279	0.092	0.051	0.558	0.022	0.062	0.004	0.153	0.187	**0.772**	
F11.	COMIMP	0.022	0.003	0.014	0.091	0.037	0.001	0.001	0.002	0.043	0.074	**0.586**

* Diagonal values are Average Variance Extracted (AVE) calculated from the measurement model.
** One measurement item dropped.

Common Method Bias

I have used different techniques to limit the magnitude of common method bias (CMB) during data collection, i.e. ex-ante, as well different techniques to measure the magnitude of common method bias ex-post. In this section, I elaborate different measures I have taken. Further details are reported in Appendix B.

<u>Survey Design</u>

I have used different ways to limit common method bias during the data collection, such as asking about dependent variables separately from independent variables, in an order which makes it difficult for respondents to think of a desirable answer for the researchers, or offering different types of questions for the same variable, such as offering open range questions for transaction cost estimates and predetermined categories.

One Factor Test

To test whether common method bias is an issue in our study, I perform Harman's one factor test, (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). I try to show that whether one factor can explain all of the variance in the data. The unrotated confirmatory factor analysis with measurement items of multi item variables such as MT, PPCSpec, OEMTSI, TECUNC, MOD, DIFF , INTRES, SUPTEC, SUPTSI, and PE_Out with only one factor results in a factor that is not capable of explaining the majority of variance in data. The proportion of the factor is 0.395 which is below 0.5. As a result, there is no one factor, including common method, that can explain all variation in the study.

Common Latent Factor

In the next step, I use the common latent factor method (Podsakoff et al., 2003) to check whether common method bias is present in the form of a common latent factor explaining the variation in most key variables of the study. I set up a measurement model, using the variables that I used for one factor test. Based this method, I add a common latent factor which is correlated with all of the measurement items, with a constrained loading. The calculated common method variance is 0.7%[9].

Marker Variable

Furthermore, I perform the marker variable method (Podsakoff et al., 2003). In this method, a marker variable with no correlation with key variables is added, and the common latent factor is calculated. Any increase in the common method variance is an indication of CMB existence. I add the marker variable, HET, which has low correlation with the other latent variables conceptually. HET is a seemingly unrelated variable to the rest of key variables. HET measures the degree to which the OEM's customers are heterogeneous. Upon adding this marker variable, the common method variance reduces to 0.6%. The percentage of the common method variance before and after adding the marker variable is negligible. Therefore, I do not find any evidence for common method bias in this study. Further details are reported in Appendix B.

Variables Correlation Matrix

Table 5-8 illustrates the correlation matrix and the significance level of the correlation coefficients for variables used in this study.

[9] It is the squared value of unstandardized common factor loading, expressed in percentage.

Table 5-8. Correlation Matrix

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.
1. PPCSpec	1																												
2. Log(D+1)	.211	1																											
3. Log(M+1)	.279	.552	1																										
4. Log(W+1)	.427	.617	.466	1																									
5. LogG	.393	.835	.726	.868	1																								
6. MT	.325	.072	.174	.222	.201	1																							
7. PE_Out	.319	.090	.092	.183	.141	.269	1																						
8. OEMTSI	.510	.320	.410	.463	.499	.385	.317	1																					
9. TECUNC	-.159	-.134	-.140	-.100	-.146	.007	-.011	-.040	1																				
10. MOD	-.119	-.006	-.053	-.028	-.044	-.060	-.040	-.095	-.121	1																			
11. MXMd	-.150	-.263	-.212	-.240	-.274	-.189	-.093	-.277	-.022	.029	1																		
12. LC	.024	-.069	.074	.020	.012	.198	-.121	.046	-.115	.077	-.049	1																	
13. DIFF	.215	.106	.096	.111	.113	.094	.549	.143	.120	-.050	-.072	-.289	1																
14. INTRES	.425	.213	.210	.334	.317	.370	.532	.367	-.144	-.066	-.103	.022	.399	1															
15. NKEYCOM	.022	.034	.015	.003	.013	-.017	-.029	.036	.054	-.134	-.020	-.078	-.002	.061	1														
16. NPOTSUP	-.124	-.057	-.035	-.060	-.070	.013	-.034	-.113	.060	-.062	.064	-.017	.003	-.035	-.002	1													
17. SUPTEC	.307	.215	.195	.261	.277	.183	.222	.385	.079	-.074	-.217	-.024	.188	.194	.076	-.027	1												
18. SUPTSI	.477	.248	.336	.437	.414	.358	.230	.663	-.051	-.107	-.206	.056	.087	.377	.098	-.104	.400	1											
19. TENURE	-.048	-.082	.005	-.144	-.091	.009	-.058	-.013	-.106	-.007	.039	-.056	-.015	-.052	-.043	.049	.004	-.039	1										
20. TRANSCOPE	.309	.327	.219	.308	.354	.201	.125	.371	-.103	-.061	-.097	-.009	.137	.230	.085	-.070	.332	.259	.026	1									
21. COMPRAT	.081	.085	.075	.023	.064	.060	-.063	.224	-.025	.068	-.135	.183	-.121	-.061	-.033	-.061	.052	.107	-.035	-.006	1								
22. OEMSIZE	.123	.141	.104	.207	.188	.080	-.009	.175	-.004	.034	-.058	-.014	-.032	.054	-.008	-.015	.052	.135	-.021	.117	-.024	1							
23. SUPSIZE	.063	.082	.097	.069	.081	.045	.022	.045	-.027	.029	-.033	-.003	-.007	.041	-.015	-.010	.059	.039	.002	-.018	.029	.300	1						
24. TRANFREQ	.097	.052	.113	.005	.050	.137	.079	.185	-.147	.012	.011	.017	.012	.098	-.027	-.020	-.045	.136	.159	.165	.106	-.044	-.038	1					
25. FINFREQ	-.053	.190	.254	.097	.190	.084	-.090	.091	-.156	.005	-.105	-.032	-.030	-.042	-.017	-.002	-.004	.107	.126	.069	-.002	-.020	-.025	.154	1				
26. COMIMP	.127	.058	.124	.086	.109	.072	.099	.250	-.100	.039	-.124	.128	-.021	-.031	-.036	-.221	.185	.226	.016	.170	.293	.038	.026	.171	.038	1			
27. PROIMP	-.057	.030	.031	-.053	-.022	.073	-.065	.037	-.045	.027	-.075	.118	-.113	-.021	.029	.013	.070	.099	.072	.144	.109	.058	.010	.120	.043	.393	1		
28. UNPINN	.100	.178	.230	.145	.219	-.085	.033	.181	-.084	.007	-.135	-.067	.042	-.073	.096	-.002	.199	.074	.007	.059	-.057	.012	.015	.028	.075	.037	-.081	1	
29. HET	.126	.003	.074	.104	.075	.125	.193	.141	-.216	-.059	-.001	.238	.156	.176	-.117	-.080	.011	.114	.002	.077	.039	.002	.039	.205	.026	.107	-.028	-.110	1

Note 1) All correlation coefficients with absolute value over 0.1 are significant at $p<0.05$.

Chapter Six Explaining the Choice of Product Performance Contract Specificity

The empirical model in this dissertation has three main parts. In Chapter Six, I estimate product performance contract specificity. In Chapter Seven, I estimate the effect of deviations from optimal product performance contract specificity on the contracting performance or transaction costs. At the final stage, in Chapter Eight, I estimate the effect of governance, strategy, resources, and ex-post disputes on product performance.

Empirical Model to Estimate Product Performance Contract Specificity

Product Performance Contract Specificity: In the first stage, the Product Performance Contract Specificity (PPCSpec) is estimated based on four different exogenous variables as shown in the Figure 4-2, one endogenous variable, and the control variables. These four exogenous variables are: OEM's transaction specific investments (OEM TSI), technological uncertainty, product modularity, and component mixing and matching. The right hand side endogenous variable in the estimation of the product performance contract specificity is monitoring technology which is used to monitor the performance of the product. The interaction term of OEM TSI and technological uncertainty is added following Heide, (2003) and Williamson, (1985), in order to control for the greater hold-up problems at higher levels of uncertainty when specific assets are deployed. The interaction of mixing-and-matching dummy and modularity is also added, since modular products would make it easier to diagnose failures and lower disputation costs, thus reducing the need for more specific contracts. The other control variables are either transaction level or OEM level ones. The transaction level variables are the tenure of the relationship with the supplier, the transaction scope, the ratio of the component price over product price, transaction size, frequency of financial transaction in a span of a year, the perceived importance of the component, and finally the supplier's technology, i.e. standard vs. patented. The OEM level control variables are OEM and supplier firm size in dollar value of the sales in logarithmic scale and their interaction term, number of key components in the product, and the key product importance.

I have collected two observations per firm. In order to account for possible inter-correlation between the two observations of a firm, I use generalized least squares (GLS) method as the estimation method for product performance contract specificity. This technique estimates the error structure, and takes those estimates of error structure into account for calculation of coefficients. Thus statistically, the coefficients are more consistent and efficient using this approach, compared to ordinary least squares (OLS) method. In OLS, the error structure is assumed to be homoskedastic and without any autocorrelation. Given that there are two data points from the same OEM in our data, OLS is not consistent and efficient. It is because we expect the observations from the same firm be correlated. This set up is essential in controlling the OEM level effects

(Heide, 2003; Ruester & Neumann, 2009). Equation (6-1) illustrates the model for estimating the product performance contract specificity.

$$PPCSpec_{ij} = \beta_0 + \beta_1 \times OEMTSI_{ij} + \beta_2 \times TECUNC_i + \beta_3 \times TECUNC_i \times OEMTSI_{ij} + \beta_4 \times MT_i + \beta_5 \times MXM_{ij} + \beta_6 \times MOD_i + \beta_7 \times MODi \times MXM_{ij} + B_8 \times \text{Transaction-level Control Variables}_{ij} + B_9 \times \text{OEM-level Control Variables}_i + \delta_i + \varepsilon_{ij} \quad (6\text{-}1)$$

In equation (6-1) above, the index i refers to the OEM and j refers to the suppliers. β_0 is the intercept coefficient. β_1 to β_7 are coefficients of interest for OEM TSI, technology uncertainty, the interaction term of OEM TSI and technology uncertainty, monitoring technology, mixing-and-matching dummy (mxmd), modularity, the interaction of the mixing-and-matching dummy and modularity, respectively. The interaction term of OEM TSI and technology uncertainty is added, because under the uncertain conditions OEM needs higher safeguards for its transaction specific investments (Wooldridge, 2000). β_4 is the coefficient of the predicted levels of monitoring technology, $\widehat{MT}$. The monitoring technology is separately estimated in equation (6-2) below. B_8 and B_9 are the coefficient matrices for the control variables. The regression error is modeled as $\eta_{ij} = \delta_i + \varepsilon_{ij}$. A random effect δ_i captures unobserved OEM level variation - the regression being identified since we have two observations per OEM. ε_{ij} is distributed normally with mean zero.

Operationally, I use XTREG command in STATA 14 to estimate PPCSpec. To be able to use this command I first define the dataset as a panel data, with the firm being the panel variable, and supplier observations being the time variable. Without any intention to present different supplier observations as longitudinal observations, I use this data structure to be able to account for any possible case of serial correlation and heteroskedasticity. Doing so enables me to account for the correlations between the first and second observations, i.e. supplier A and B.

Reflection on PPCSpec Estimation

Contracting Performance: In the next chapter, the OEM's contracting performance is assessed based on the transaction costs. The idea is to estimate the contractual transaction costs both ex-ante and ex-post. These are ex-ante contract writing cost, ex-post monitoring cost, and ex-post disputation cost. In H_5 to H_8, I propose that the optimal CS, and deviation from optimal CS to be exact, can be predictors of each transaction cost. However, as discussed in the theory chapter, for the OEM, the optimal CS is the one that minimizes the total transaction costs, or the governance cost (G). As a result, there is an endogeneity between transaction costs and PPCSpec.

I account for endogeneity in our data by using two-stage least square (2SLS) in the estimation of each TC, and that is why I use exogenous variables to estimate PPCSpec, i.e. equation (6-1). Moreover, I estimate all transaction costs simultaneously, using three stage least square (3SLS). By doing so, I correct the 2SLS coefficients by taking into the account the correlation among the errors from each of the three TCs. Durbin-Wu-Hausman test (Roy et al., 2015) indicates that endogeneity between PPCSpec and TCs exist, and the choice of method for estimation of TC is right. To set up this test, I regress each TC on $\hat{\eta}_{ij}$, and the predicted levels of product performance contract specificity both predicted from equation (6-1). The coefficient of $\hat{\eta}_{ij}$ is significant in all three equations, suggesting the endogeneity exists between CS and TCs.

Appropriateness of Instrumental Variables (IV) in Monitoring Technology Estimation

As it is evident in equation (6-1), I use predicted values of monitoring technology, $\widehat{MT}$, in the estimation of PPCSpec. In this section, I elaborate the reasons of using instrumental variables to predict MT.

<u>Endogeneity issue between PPCSpec and MT</u>

I estimate monitoring technology using a set of instrumental variables (IV). The reason behind using predicted values of MT in estimation of PPCSpec is the possible endogeneity between the choice of monitoring technology and levels of PPCSpec[10]. The

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[10] Wu-Hausman Test: I perform Wu-Hausman test to detect the possible endogeneity between MT and PPCSpec. While I cannot show that there is evidence for endogeneity, I still use the predicted values of MT in the estimation of PPCSpec. At the end of this chapter, I report the estimation results of PPCSpec, using MT as an exogenous variable.

OEM may choose to invest in monitoring technology based on the level of complexity of the product performance contracts with the suppliers. As a result, I choose a number of IVs to estimate monitoring technology. These IVs are conceptually correlated with MT and uncorrelated with PPCSpec.

Instrumental Variables

The set of IVs includes OEM's integrative resources (INTRES) which are processes that the firm deploys to create higher value for the customers. The basis of such processes work on the flow of information and knowledge to understand and create higher value for the customers (Roy et al., 2015). Such internal processes are beneficial for the firm if they are tied to technologies such as product monitoring technology. The absence of vital information about the product usage can render such processes useless in their value creation design. On the other hand, the presence or even the absence of such internal processes is less of a concern for managing performance contracts with component suppliers.

Then, low-cost (LC) and differentiation strategies (DIFF) --(*cf*. Ghosh &John, 2009), these variables are in line with the perspective that value enhancing investments like these are mostly driven by the firms' strategic posture (Ghosh & John, 2005). Furthermore, while they argue that the choice of business strategy moderates the role of governance form on performance outcomes, it cannot be a predictor of the governance form. In their empirical study, they show that firms with high differentiation strategy can benefit from less stringent contracts if they are targeting product enhancement, and they can also benefit from more stringent contracts if they are targeting cost reduction goals.

Unpredictability of innovation in the industry (UNPINN) is another IV. Since investments like these tend to be sticky, the OEM faces an additional risk of losing its sunk costs if technology protocols were to suddenly change - a particular concern for emerging and innovative technologies like the IOT. Have in mind that such technologies are less transaction specific investments if any at all. On the other hand, the level of product performance contract specificity can be predicted by technology uncertainty-technologies which are more transaction specific. Thus, the unpredictability of innovation in the industry should not be a good predictor of product performance contract specificity with suppliers.

The other IVs are supplier's transaction specific investments (SUPTSI), and the number of potential suppliers (NPOTSUP). Investment in technology has the potential to make fundamental changes to the vertical relationships. Much of this comes in the form of hold-up risks if the OEM investments are non fungible outside of the partner relations. Such concerns are ameliorated if the partners (suppliers) have investments with the OEM that cannot be easily redeployed outside the relationships. The balancing nature of such investments offers greater protection to the OEM's own investments in realizing productive value of the relationships (Ghosh & John, 2005). I index this with two variables corresponding to the Suppliers' transaction specific investments ($SUPTSI1_i$ and $SUPTSI2_i$ corresponding to the two key component suppliers identified by the OEM*i*). The OEM is likely also motivated by scale economies driven by production cost sensitivities. For this I include two variables that capture the number of potential component suppliers for the two key components identified by the OEM ($NPOTSUP1_i$ and $NPOTSUP2_i$). Despite their value appropriation nature, these two variables do not have any predictive potential of the product performance contract specificity with the suppliers. That's because the OEM offers contracts based on its own transaction specific investments and not the supplier's investments. Remember our initial principal and agent perspective in modeling the relationship. Moreover, the number of potential suppliers defines the supply side competition. Such competition levels should only affect the price levels and not pricing policies. The latter is one of our items in our measurement of product performance contract specificity.

$$MT_i = \alpha_0 + \alpha_1 \times INTRES_i + \alpha_2 \times LC_i + \alpha_3 \times DIFF_i + \alpha_4 \times UNPINN_i + \alpha_5 \times SUPTSI1_i + \alpha_6 \times SUPTSI2_i + \alpha_7 \times NPOTSUP1_i + \alpha_8 \times NPOTSUP2_i + \mu_i \quad (6\text{-}2)$$

I use OLS to estimate equation (6-2), where μ_i is the normally distributed error term. I then estimate the predicted level of monitoring technology, $\widehat{MT_\iota}$. The index i refers to OEMs. The estimation results are reported in Table 6-4.

Sargan Test

To ensure that choices of IV for MT are uncorrelated with PPCSpec, I predict the error term η_{ij} in equation (6-2), and regress it on the set of IVs for MT. These IVs should not be able to explain η_{ij}. This is to ensure that the IVs are appropriate.

Table 6-1. IV Endogeneity Test

DV: error term from PPCSpec estimation, η_{ij}

Variable	Coeff.		SE	z
$INTRES_i$	.041		.064	.64
LC_i	-.021		.046	-.45
$DIFF_i$	.035		.064	.55
$UNPINN_i$	-.013		.050	-.26
$SUPTSI_{ij}$	.082	***	.031	2.68
$NPOTSUP_{ij}$	.000	***	.000	-3.04

Model Fit: Wald $\chi 2$ (6) = 23.30***
Estimation Method: GLS, Random Effect (N=344)
*p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

While the model fit is significant, most coefficients are insignificant, except for supplier transaction specific investments (SUPTSI) and number of potential suppliers (NPOTSUP). These two variables are weak IVs while the rest of the IVS are strong ones. Since the number of strong IVs is more than one in this case, therefore, the identification criterion is still satisfied. Note that there are three strong IVs, i.e. INTRES, LC, and UNPINN, and there is only one dependent variable, i.e. MT. To make sure the presence of weak IVs does not disturb the results in this chapter and next chapter, I estimate MT using only strong IVs identified. All results remain unchanged. Table 6-2 provides the results of identification test, after removing the weak IVs.

Table 6-2. IV Endogeneity Test After Dropping Weak IVs

DV: error term from PPCSpec estimation, η_{ij}

Variable	Coeff.	SE	z
$INTRES_i$	.021	.060	.35
LC_i	-.041	.045	-.93
$DIFF_i$	.028	.062	.46
$UNPINN_i$	.005	.048	.11

Model Fit: Wald $\chi 2$ (4) = 2.07
Estimation Method: GLS, Random Effect (N=344)
*p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

As it is evident in Table 6-2 after removing the weak IVs, the rest of IVs still remain uncorrelated with PPCSpec. There is however a major limitation with such tests- that they cannot directly test for correlation of the instruments with the structural error.

Results

Product Performance Contract Specificity Estimation Results

As it is evident in Table 6-3, I find empirical supports for the hypotheses related to role of OEM TSI, Technology Uncertainty, modularity, mixing-and-matching, and monitoring technology on CS. The effect of OEMTSI on CS is positive and significant (β_1 = 0.223, p<0.05), therefore, H_1 is supported. The effect of technology uncertainty on CS is negative and significant (β_2 = -0.377, p<0.05), hence H_2 is supported. The effect of modularity on CS is not significant, supporting the idea that dispute related effect and monitoring related effect possibly cancel out each other, and hence, I do not observe any significant effect on CS. Note that I obtain this result after dropping one measurement item with low loading form Modularity measurement scale. To compare results of the case where I do not drop a measurement item, refer to end of this chapter. The effect of mix-and-match on CS is positive and significant (β_5=0.944, p<0.01). Thus H_3 is supported. The effect of monitoring technology, i.e. $\widehat{MT}$, on CS is positive and significant ($\beta_{4=}$ 0.233, p<0.01). Therefore, H_4 is supported.

Table 6-3. Antecedents of Product Performance Contract Specificity

DV: Product Performance Contract Specificity, $PPCSpec_{ij}$				
Variable	Coeff.		SE	z
$OEMTSI_{ij}$	.223	**	.104	2.15
$TECUNC_{i}$	-.377	**	.153	-2.47
$TECUNC_{i}\times OEMTSI_{ij}$	.065	*	.036	1.80
$\widehat{MT}_{i}$	.233	***	.087	2.67
MXM_{ij}	.944	***	.312	3.03
MOD_{i}	.106		.076	1.40
$MOD_{i}\times MXM_{ij}$	-.259	***	.079	-3.27
$TENURE_{ij}$	.003		.005	.66
$TRANSCOPE_{ij}$	.057		.035	1.62
$COMRAT_{ij}$	.354		.221	1.60
$LOGOEMSIZE_{i}$	.100	**	.041	2.43
$LOGSUPSIZE_{ij}$	.020		.032	.63
$LOGOEMSIZE_{i}\times LOGSUPSIZE_{ij}$	-.011	*	.007	-1.66
$FINFREQ_{ij}$	-.000		.000	-1.44
$NKEYCOM_{i}$	-.000		.000	-.00
$SUPTEC_{ij}$	.030		.031	.99
$COMIMP_{ij}$	.092	**	.043	2.15
$PROIMP_{i}$	-.127	**	.060	-2.13

Model Fit: Wald $\chi 2$ (18) = 277.42***
Estimation Method: GLS, Random Effect (N=344)
*p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

Monitoring Technology Estimation Results

Table 6-4 presents the coefficients for the instrumental variable to estimate monitoring technology. I have also reported the F-test statistics. This test statistic shows whether the coefficients are different than zero. The significant level of the test shows at least one coefficient is different than zero. Also note that in this model, I have dropped on measurement item from differentiation variable to improve alpha. I redo the results in the end of this chapter to compare the results.

Table 6-4. Monitoring Technology Estimation Results

DV: Monitoring Technology, MT_i

Variable	Coeff.		SE	t
$INTRES_i$	.284	***	.105	2.70
LC_i	.191	***	.068	2.79
$DIFF_i$	.060		.119	0.50
$UNPINN_i$	-.151	*	.078	-1.94
$SUPTSI1_i$	.316	***	.096	3.29
$SUPTSI2_i$	.062		.092	0.67
$NPOTSUP1_i$	.015	***	.006	2.63
$NPOTSUP2_i$	.000		.000	0.61

Model Fit: Adjusted R^2=0.2870; F (8) =9.56**
Estimation Method: OLS (N=199)
*p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

As it is evident in Table 6-4, Integrative Marketing Resources, Transaction Specific Investments of Supplier 1, potential number of suppliers for component 1, and firm's low-cost strategy are the parameters which increase the level of the product monitoring technology. These are the variables with significant coefficients. On the other hand, the unpredictability of the innovation in the product technology is the only parameter that decreases the level of monitoring technology. The results suggest that the component 1 is a better predictor of monitoring technology. It could be because component 1 is the more important key component between the two observation points. Or, as the OEM has experienced a major failure on component 1, they are paying more attention to it. Overall, the over-identification of IVs is achieved since the model fit index, i.e. F-test, is significantly different than zero and there is more than one significant coefficient. I will test whether these IVs are uncorrelated with PPCSpec after the estimation of PPCSpec.

Once the predicted value of the monitoring technology is calculated, i.e $\widehat{MT}$, I estimate equation (6-1). The effect of each antecedent on PPCSpec is presented as follows.

Re-estimation of PPCSpec with MT as an Exogenous Variable

To test whether treating monitoring technology, MT, as an exogenous variable, changes the results, I estimate PPCSpec again. The results are reported in Table 6-5.

Table 6-5. Antecedents of Product Performance Contract Specificity – MT as Exogenous Variable

DV: Product Performance Contract Specificity, $PPCSpec_{ij}$

Variable	Coeff.		SE	z
$OEMTSI_{ij}$	.235	**	.103	2.29
$TECUNC_{i}$	-.403	**	.154	-2.62
$TECUNC_{i} \times OEMTSI_{ij}$	.064	*	.036	1.79
MT_{i}	.108	***	.043	2.50
MXM_{ij}	.946	***	.311	3.04
MOD_{i}	.094		.076	1.25
$MOD_{i} \times MXM_{ij}$	-.264	***	.079	-3.34
$TENURE_{ij}$	.003		.005	.65
$TRANSCOPE_{ij}$	.052		.035	1.48
$COMRAT_{ij}$	.350		.219	1.60
$LOGOEMSIZE_{i}$	.105	**	.041	2.58
$LOGSUPSIZE_{ij}$	.012		.031	.38
$LOGOEMSIZE_{i} \times LOGSUPSIZE_{ij}$	-.011	*	.007	-1.68
$FINFREQ_{ij}$	-.000		.000	-1.34
$NKEYCOM_{i}$	-.000		.000	-.11
$SUPTEC_{ij}$	.036		.030	1.20
$COMIMP_{ij}$	.093	**	.043	2.17
$PROIMP_{i}$	-.119	**	.060	-2.01

Model Fit: Wald $\chi 2$ (18) = 279.72***
Estimation Method: GLS, Random Effect (N=346)
*p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

As illustrated in Table 6-5, there is no major change in significance level of results. All hypotheses are still supported.

Chapter Seven Explaining Transaction Costs

To test the hypotheses on transaction costs, i.e. H_5 to H_8, I need to explain the transaction costs based on the deviations from optimal product performance contract specificity, while controlling for the other variables. In previous chapter, I presented how I have predicted the optimal product performance contract specificity. Now, I argue that any positive deviations from that predicted level of product performance contract specificity can be regarded as over-specification, and a negative deviation as under-specification. Mooi & Ghosh, (2010) use a similar approach to estimate the impact of deviations from optimal contract design on contracting costs and transaction problems, in the context of IT infrastructure investments. Similarly, (Ferguson et al., 2005; Poppo & Zhou, 2014) use the same concept of deviations from formal contracting on product performance. They estimate end product enhancement and cost reduction goals using the deviations from formal contracting. Neither of these studies considers the impact of deviations on ex-post monitoring cost. In this study, I uncover the trade-off between the ex-post transaction costs, i.e. monitoring and dispute costs, with respect to product performance contract specificity.

Such deviations from optimal product performance contract specificity exist because managers may make a calculation error, or they exist because of some missing variables, which I have not controlled for in the estimation of product performance contract specificity. Next, I present the empirical models to estimate different transaction costs. I now explain how deviations, or residuals, are estimated.

Empirical Model

Residual Prediction: to assess the role of contract over-specification and under-specification on TC, I use the estimated parameters to calculate the predicted product performance contract specificity, $\widehat{CS}_{ij}$. Then I calculate the deviations of observed product performance contract specificity from this optimal estimate: $\widehat{\eta_{ij}} = CS_{ij} - \widehat{CS}_{ij}$. To test the impact of deviations on transaction costs, I normalize deviation as $dev_{ij} = \widehat{\eta_{ij}} / \widehat{CS}_{ij}$ and then use it as one of the regressors of transaction costs.

$$CS_{ij} = \widehat{CS}_{ij} + \hat{\eta}_{ij} \tag{7-1}$$

$$\hat{\eta}_{ij} = CS_{ij} - \widehat{CS}_{ij} \tag{7-2}$$

$$dev_{ij} = \widehat{\eta_{ij}} / \widehat{CS}_{ij} \tag{7-3}$$

A positive predicted error term, $\hat{\eta}$, is an indication of over-specification of the contract, while a negative predicted error term, $\hat{\eta}$, is an indication of under-specification of the contract. By adding the predicted deviation term, *dev* to the estimation of each TC, the coefficient of *dev* is the coefficient of interest to support or reject H_6, H_7, and H_8. Likewise, the coefficient of *dev* and its squared term are coefficients of interest in H_5.

Total Governance Cost Estimation

H_5 suggests that any deviation, positive or negative, leads to higher total governance cost. To test this non-linear relationship between total governance cost, G, and deviation, dev, I regress natural logarithm of G on deviation and its squared term. In a case of a symmetric non-linear relationship, the coefficient of dev needs to be insignificant, where as I expect to see a significant coefficient of dev^2. Meanwhile, I control for fixed firm effects, and the level of optimal product performance contract specificity.

$$Governance_{ij} = \beta 0 + \beta 1\times dev_{ij} + \beta 2\times (dev_{ij})^2 + \beta 3\times PP\widehat{CSpec}_{ij} + B4\cdot FirmD_i + \upsilon_{ij} \qquad (7\text{-}4)$$

I expect that β_1 be insignificant, while β_2 be positive and significant. The estimation results are reported as follows. Index "i" refers to the OEM, and "j" refers to supplier.

Individual Transaction Costs Estimation

To investigate the impact of deviations on each transaction cost in H_6, H_7, and H_8, I regress log transformation of Dispute cost, $logD'_{ij}=Log(D_{ij}+1)$, Contract Monitoring Cost, $logM'_{ij}=Log(M_{ij}+1)$, and Contract Writing Cost, $logW'_{ij}=Log(W_{ij}+1)$, on deviation, dev_{ij}, in a linear specification, while controlling for optimal level of product performance contract specificity, supplier and OEM fixed effects. The reason of adding a one unit of man-day to each transaction cost before logarithm transformation is to avoid losing data point as a missing data where the reported transaction cost is zero. Given the open range of the measurement of the transaction costs, this should cause no serious data distortion. Moreover, I test for the robustness of the estimation using a simple logarithm transformation, after the initial estimation. I have collected two data points per each OEM. Supplier 1 is the supplier which the OEM has experienced a major component failure, and supplier 2 is the one which the OEM has experienced minor failures if any. Index "i" refers to the OEM, and "j" refers to supplier. The dummy variable used for supplier is one for supplier 2, and is zero otherwise. I control for any systematic variation which is attributable to the OEM identities by using a dummy variable for the OEMs. Equations (7-5) to (7-7) illustrate the specification of each transaction cost.

$$Dispute_{ij} = \beta_{10} + \beta_{11} \times dev_{ij} + \beta_{12} \times \widehat{PPCSpec}_{ij} + \beta_{13} \times SupplierD_j + B_{14} \cdot FirmD_i + \beta_{15} \times Monitoring_{ij} + \upsilon_{1ij} \tag{7-5}$$

$$Monitoring_{ij} = \beta_{20} + \beta_{21} \times dev_{ij} + \beta_{22} \times \widehat{PPCSpec}_{ij} + \beta_{23} \times SupplierD_j + B_{24} \cdot FirmD_i + \upsilon_{2ij} \tag{7-6}$$

$$Writing_{ij} = \beta_{30} + \beta_{31} \times dev_{ij} + \beta_{32} \times \widehat{PPCSpec}_{ij} + \beta_{33} \times SupplierD_j + B_{34} \cdot FirmD_i + \beta_{35} \times TRANFREQ_{ij} + \upsilon_{3ij} \tag{7-7}$$

I estimate these three equations simultaneously, using three stage least square (3SLS) method. This method allows taking into account the error covariance across the equations. Moreover, I can control for the endogeneity between monitoring and dispute costs. Potentially high disputes can lead to higher monitoring. Also by more strict monitoring there will be more cases of discrepancies discovered, which potentially leads to more disputes with the supplier. For the system of simultaneous equations be identified, I add transaction frequency, $TRANFREQ_{ij}$ to the right hand side of equation

(7-7). Based on the hypotheses H_6, H_7, and H_8, I expect $\beta_{11} < 0$, $\beta_{12} > 0$, and $\beta_{13} > 0$, and significant.

Results

Total Governance Cost Estimation Results

The estimation results of total governance cost, equation (7-4), are reported in Table 7-1 panel (a) below. As expected β_1 is insignificant, and more importantly, β_2 is positive and significant (β_2=2.499, $p<0.05$). H_5 is supported. Any positive or negative deviation from the optimal level of product performance contract specificity is associated with higher total cost of governance.

Table 7-1. Impact of Contract Deviation on Transaction Costs, Using Log(TC+1) Transformation for all DVs Expect for Total Transaction Cost, G_{ij}

	(a) Total Governance Cost **DV: Log(G_{ij})**			(b) Ex-post Disputation Cost **DV: Log(D_{ij}+1)**			(c) Ex-post Monitoring Cost **DV: Log(M_{ij}+1)**			(d) Ex-ante Contract Writing Cost **DV: Log(W_{ij}+1)**		
Variable	**Coeff.**	**SE**	**t**	**Coeff.**	**SE**	**z**	**Coeff.**	**SE**	**z**	**Coeff.**	**SE**	**z**
dev_{ij}	.415	.315	1.32	-.827 **	.364	-2.27	.277 **	.133	2.08	.736 ***	.179	4.11
$(dev_{ij})^2$	2.499 **	.992	2.52									
$\widehat{CS}_{ij}$	.764 ***	.084	9.05	-.597 ***	.170	-3.50	.222 ***	.039	5.67	.614 ***	.052	11.75
Supplier D_{ij}				.044	.073	.60	-.057 ***	.027	-2.15	-.075 ***	.036	-2.12
Log(M_{ij})				4.034 ***	.639	6.31						
$TRANFREQ_{ij}$										-.036	.025	-1.44
Firm D_i	Not Shown			Not Shown			Not Shown			Not Shown		
Model Fit:	Adjusted R^2=0.9358; F (174) =14.15***			$\chi2$ (175)= 1935.25***			$\chi2$ (174)= 5509.83***			$\chi2$ (175)= 5088.90***		
Estimation Method:	OLS, N(344)			Three Stage Least Square Regression, N(344)								

p<0.1* ** *p<0.05* * *p<0.01*

Intercepts not shown.

<u>Individual Transaction Costs Estimation Results</u>

As illustrated in Table 7-1, panels b-d, All three hypotheses germane to transaction costs are supported. The coefficient of deviation, dev_{ij}, in panel (b) i.e. ex-post Disputes, is negative and significant (-.827, $p<0.05$) as expected so H_6 is supported. The coefficient of deviation, dev_{ij}, in panel (c) in Table 7-1, i.e. ex-post Monitoring, is positive and significant (0.277, $p<0.05$) as expected so H_7 is supported. The coefficient of deviation, dev_{ij}, in panel (d) in Table 7-1, i.e. ex-ante contract Writing cost, is positive and significant (0.736, $p<0.01$) as expected, so H_8 is supported.

It means that managers' deviations from optimal level of the product performance contract specificity, for any reasons such as miscalculations, have some contrasting effect on transaction costs. An over-specification (under-specification) of the contract is associated with an increase (a decrease) in ex-ante contract writing cost, an increase (a decrease) in ex-post monitoring cost, and a decrease (an increase) in ex-post dispute costs.

As it is evident in Table 7-1, panel b, there is a positive and significant association of monitoring cost with dispute cost ($\beta_{15=}$ 4.034, $p<0.01$). As explained before, I expected them to be correlated. In situations that call for high monitoring because of high potential ex-post disputes, the OEM may try to decrease the level of monitoring cost by drafting a less specified contract, which in turn, fuels up the disputes.

Re-estimation of the Results with other Data Transformation Techniques

Recall that to avoid losing many data points because of logarithm transformation, I add "1" man-day to each observed costs before logarithm transformation. Doing so, I don't lose the observation after logarithm transformation where the initial observation has been zero. To assess whether the way I use logarithm transformation on each individual transaction cost has any effect on the results, I re-estimate equations (7-5) to (7-7), using first simple logarithm transformation of D_{ij}, M_{ij}, and W_{ij}, and second, normalized[11] value of each transaction cost. Thereby, I generate two extra versions of transaction cost estimation results. They are reported in Table 7-2 and Table 7-3.

I present the results of the simple logarithm transformation in Table 7-2. In this version, I do not add "1" man-day to any transaction cost prior to the transformation. Evidently, there is a drop in observation numbers in panels b-d. However, all significance levels remain the same, except for the coefficient of deviation in panel c, explaining ex-post monitoring cost. The significance level drops, but it is still significant at ($p<0.1$), see panel b in Table 7-2 (0.444, $p<0.1$).

Furthermore, I mean center each transaction cost, and report the transaction cost estimation in Table 7-3. The total transaction cost G_{ij} is the sum of mean centered D_{ij}, M_{ij}, and W_{ij}. Using this data manipulation technique I find support for H_6 and H_8. The coefficient of deviation, dev_{ij}, in panel (b) in Table 7-3, i.e. ex-post Disputes, is negative

[11] Mean centered.

and significant (-.497, $p<0.05$) as expected so H_6 is supported. The coefficient of deviation, dev_{ij}, in panel (d) in Table 7-3, i.e. ex-ante contract Writing cost, is positive and significant (0.602, $p<0.05$), so H_8 is supported. However, H_5 (negative and insignificant coefficient where positive is expected) and H_7 (positive coefficient as expected yet insignificant) are not supported.

Table 7-2. Impact of Contract Deviation on Transaction Costs, Using Log(TC) Transformation for all DVs

	(a) Total Governance Cost **DV: Log(G_{ij})**			(b) Ex-post Disputation Cost **DV: Log(D_{ij})**			(c) Ex-post Monitoring Cost **DV: Log(M_{ij})**			(d) Ex-ante Contract Writing Cost **DV: Log(W_{ij})**		
Variable	**Coeff.**	**SE**	**t**	**Coeff.**	**SE**	**z**	**Coeff.**	**SE**	**z**	**Coeff.**	**SE**	**z**
dev_{ij}	.415	.315	1.32	-1.432 **	.573	-2.50	.444 *	.237	1.87	1.426 ***	.298	4.79
$(dev_{ij})^2$	2.499 **	.992	2.52									
$\widehat{CS}_{ij}$	.764 ***	.084	9.05	-.832 ***	.203	-4.09	.323 ***	.056	5.75	.853 ***	.070	10.79
Supplier D_{ij}				.049	.099	.49	-.105 ***	.038	-2.76	-.124 ***	.047	-2.61
Log(M_{ij})				3.566 ***	.497	7.17						
$TRANFREQ_{ij}$										.027	.038	.71
Firm D_i	Not Shown			Not Shown			Not Shown			Not Shown		
Model Fit:	Adjusted R^2=0.8696; F (174) =14.15***			$\chi2$ (142)= 1696.60***			$\chi2$ (141)= 5024.82***			$\chi2$ (142)= 4932.00***		
Estimation Method:	OLS, N(344)			Three Stage Least Square Regression, N(258)								

**p<0.1* *** p<0.05* **** p<0.01*
Intercepts not shown.

Table 7-3. Impact of Contract Deviation on Transaction Costs, Using Mean Centered Standardized Measures for all DVs

	(a) Total Governance Cost DV: NG_{ij}			(b) Ex-post Disputation Cost DV: ND_{ij}			(c) Ex-post Monitoring Cost DV: NM_{ij}			(d) Ex-ante Contract Writing Cost DV: NW_{ij}		
Variable	**Coeff.**	**SE**	**t**	**Coeff.**	**SE**	**z**	**Coeff.**	**SE**	**z**	**Coeff.**	**SE**	**z**
dev_{ij}	.255	.733	.35	-.497 **	.240	-2.07	.052	.246	.21	.602 **	.270	2.23
$(dev_{ij})2$	-.519	2.307	-.22									
$\widehat{CS}_{ij}$	.793	.196	4.04	-.150 ***	.075	-2.01	.134 *	.072	1.85	.496 ***	.079	6.28
Supplier D_{ij}				-.023	.052	-.44	-.106 **	.049	-2.14	-.022	.054	-.42
$Log(M_{ij})$				1.041 ***	.182	5.72						
$TRANFREQ_{ij}$										-.012	.039	.30
Firm D_i	Not Shown			Not Shown			Not Shown			Not Shown		
Model Fit:	Adjusted R^2=0.7404; F (174) =6.62***			$\chi2$ (175)= 2284.03***			$\chi2$ (174)= 1978.39***			$\chi2$ (175)= 1625.75***		
Estimation Method:	OLS, N(344)			Three Stage Least Square Regression, N(344)								

**p<0.1*   *** p<0.05*   **** p<0.01*
Intercepts not shown.

Chapter Eight Explaining Product Performance

In this chapter, I explore the relationship between the ex-post dispute costs and product performance outcomes. Using an empirical model, I find support to hypotheses H_9 and H_{10}. I use a system of equations for my empirical model, and estimate them simultaneously. The variable I use to measure product performance is Product Enhancement Outcomes (PE_Out). In this variable, I measure the outcomes that the OEM has achieved in terms of outperforming the competitors, improving quality, creating value, and product differentiation, given the way the OEM is managing its suppliers. The description of the items is reported in Appendix A.

Empirical Model to Estimate Product Enhancement Outcomes (PE_Out)

In this system of equations, I simultaneously estimate monitoring technology (MT), product performance contract specificity (PPCSpec), logarithm transformation[12] of ex-post transaction costs, i.e. monitoring (LogM') and dispute costs(LogD'), and finally product performance outcomes (PE_Out). These equations are reported in (8-1) to (8-8) below.

[12] LogM'=Log(M+1) & LogD'=Log(D+1) to avoid losing observations, where reported levels of D or M are zero.

$$PE\_Out_i = \beta_{10}+\beta_{11}\times LogD'_{i1} + \beta_{12}\times LogD'_{i2} + \beta_{13}\times LogM'_{i1} + \beta_{14}\times LogM'_{i2} + \beta_{15}\times PPCSpeci_1 + \beta_{16}\times PPCSpeci_1\times MT_i + \beta_{17}\times PPCSpeci_1\times DIFF_i + \beta_{18}\times PPCSpeci_1\times MT_i\times DIFF_i + \beta_{19}\times PPCSpeci_2 + \beta_{110}\times PPCSpec_{i2}\times MT_i + \beta_{111}\times PPCSpec_{i2}\times DIFF_i + \beta_{112}\times PPCSpec_{i2}\times MT_i\times DIFF_i + \beta_{113}\times MT_i \times DIFF_i + \beta_{114}\times MT_i + \xi 1 \quad (8\text{-}1)$$

$$LogD'_{i1} = \beta_{20}+\beta_{21}\times PPCSpeci_1 + \beta_{22}\times LogM'_{i1} + \xi 2 \quad (8\text{-}2)$$

$$LogD'_{i2} = \beta_{30}+\beta_{31}\times PPCSpec_{i2} + \beta_{32}\times LogM'_{i2} + \xi 3 \quad (8\text{-}3)$$

$$LogM'_{i1} = \beta_{40}+\beta_{41}\times PPCSpec_{i1} + \xi 4 \quad (8\text{-}4)$$

$$LogM'_{i2} = \beta_{50}+\beta_{51}\times PPCSpec_{i2} + \xi 5 \quad (8\text{-}5)$$

$$PPCSpec_{i1} = \beta_{60} + \beta_{61}\times MT_i + \beta_{62}\times OEMTSI_{i1}+ \beta_{63}\times TECUNC_i + \beta_{64}\times OEMTSI_{i1}\times TECUNC_i + \beta_{65}\times MOD_i + \beta_{66}\times TENURE_i + \beta_{67}\times TRANSCOPE_i + \beta_{68}\times COMPRAT_{i1} + \beta_{69}\times LogOEMSIZE_i + \beta_{610}\times LogSUPSIZE_{i1} + \beta_{611}\times LogOEMSIZESUPSIZE_{1i} + \beta_{612}\times FINFREQ_{i1} + \beta_{613}\times NKEYCOM_i + \beta_{614}\times SUPTEC_{i1} + \beta_{615}\times COMIMP_{i1} + \beta_{616}\times PROIMP_i + \beta_{617}\times MXMd_{i1}+ \beta_{618}\times MOD_i\times MXM_{i1} + \xi 6 \quad (8\text{-}6)$$

$$PPCSpec_{i2} = \beta_{70} + \beta_{71}\times MT_i + \beta_{72}\times OEMTSI_{i2} + \beta_{73}\times TECUNC_i + \beta_{74}\times OEMTSI_{i2}\times TECUNC_i + \beta_{75}\times MOD_i + \beta_{76}\times TENURE_i + \beta_{77}\times TRANSCOPE_i + \beta_{78}\times COMPRAT_{i2}+ \beta_{79}\times LogOEMSIZE_i + \beta_{710}\times LogSUPSIZE_{i2} + \beta_{711}\times LogOEMSIZESUPSIZE_{2i} + \beta_{712}\times FINFREQ_{i2} + \beta_{713}\times NKEYCOM_i + \beta_{714}\times SUPTEC_{i2} + \beta_{715}\times COMIMP_{i2} + \beta_{716}\times PROIMP_i + \beta_{717}\times MXMd_{i2} + \beta_{718}\times MOD_i\times MXM_{i2} + \xi 7 \quad (8\text{-}7)$$

$$MT_i = \beta_{80}+\beta_{81}\times INTRES_i + \beta_{82}\times LC_i + \beta_{83}\times DIFF_i + \beta_{84}\times UNPINN_i + \beta_{85}\times SUPTSI_{i1} + \beta_{86}\times SUPTSI_{i2} + \beta_{87}\times NPOTSUP_{i1} + \beta_{88}\times NPOTSUP_{i2} + \xi 8 \quad (8\text{-}8)$$

Since there are transaction level and OEM level dependent variables in the system, I cannot use the pseudo panel structure I had created to account for OEM level effects in Chapter Six and Chapter Seven. As a result, I use a cross section of data. Equations (8-1) to (8-8) illustrate the equations in this system of equations.

$PPCSpec_{i1}$, $PPCSpec_{i2}$, and MT_i equations, i.e. (8-6) to (8-8), are set up in exactly the same way that I estimate both monitoring technology (MT) and product performance contract specificity (PPCSpec) in Chapter Six. From Chapter Seven, I know that Dispute cost is a function of PPCSpec and also it is correlated with Monitoring Cost, so I set up equations (8-2) to (8-3) to capture these relationships. Likewise Monitoring Cost is a function of PPCSpec, so I set up equations (8-4) to (8-5) to capture these relationships.

In equation (8-1), or PE_Out_i estimation, I am interested in assessing the relationship of ex-post transaction costs, i.e. Disputes and Monitoring cost, with Product Enhancement Outcomes, while controlling for the effect of governance mechanism, i.e. PPCSpec, Firm level capabilities, i.e. MT, and firm level strategy, DIFF. I only incorporate firm level strategy, DIFF, as a moderating variable. The reason that the direct impact of differentiation on PE_Out is not studied is that firms with high or low differentiation strategy strive for higher product enhancement goals. Based on H_9 and H_{10}, my coefficients of interest in this system of equations are β_{11} and β_{12}. I expect to observe a positive β_{11} and a negative β_{12}.

I measure PE_Out by a multi-item measurement scale. The details are reported in Appendix A. In this variable, I measure the extent to which the OEM has been able to enhance the product, based on the way it manages its relationship with key component suppliers. The results of the estimation of the system of equations are presented as follows.

Results

The results of the simultaneous estimation of equations (8-1) to (8-8) are presented below, in Table 8-1 to Table 8-8.

Estimation Results

As it is evident in Table 8-1, the estimation results of MT is not different from the individual estimation of MT in Chapter Six Table 6-4, except for the fact the $UNPINN_i$ loses its significance. However, the other strong IVs, i.e. $INTRES_i$ and LC_i are still significant.

Table 8-1. Explaining Monitoring Technology in a System of Equations

DV: Monitoring Technology, MT_i

Variable	**Coef.**		**SE.**	**z**
$INTRES_i$	0.401	***	0.111	3.62
LC_i	0.210	***	0.070	3.01
$DIFF_i$	-0.021		0.120	-0.17
$UNPINN_i$	-0.120		0.080	-1.50
$SUPTSI_{i1}$	0.352	***	0.100	3.53
$SUPTSI_{i2}$	-0.059		0.094	-0.62
$NPOTSUP_{i1}$	0.013	**	0.006	2.24
$NPOTSUP_{i2}$	0.000		0.000	0.37

Model Fit: $\chi^2(8)=72.80$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

In Table 8-2 to Table 8-3, I present the estimation results of PPCSpec for both supplier A and B, in panel (a) of both tables. It is evident that most of the hypotheses that explained product performance contract specificity, i.e. H_1 to H_4, are still supported. The only hypothesis that I find partial support for is H_2, where the coefficient of $TECUNC_i$ is only significant for the observations from supplier B. Nonetheless, all other hypotheses are supported.

Table 8-2. Explaining Product Performance Contract with Supplier A
in a System of Equations

DV: Product Performance Contract Specificity with Supplier A, $PPCSpec_{i1}$

Variable	**Coef.**		**SE.**	**z**
MT_i	0.180	***	0.044	4.11
$OEMTSI_{i1}$	0.373	***	0.117	3.18
$TECUNC_i$	-0.138		0.174	-0.79
$OEMTSI_{i1}\times TECUNC_i$	-0.004		0.040	-0.11
MOD_i	0.078		0.075	1.04
$TENURE_i$	0.004		0.006	0.72
$TRANSCOPE_i$	0.066	*	0.037	1.79
$COMPRAT_{i1}$	0.147		0.245	0.60
$LogOEMSIZE_i$	0.061		0.043	1.42
$LogSUPSIZE_{i1}$	0.005		0.033	0.16
$LogOEMSIZESUPSIZE1_i$	-0.004		0.007	-0.58
$FINFREQ_i$	0.000		0.000	-1.34
$NKEYCOMP_i$	0.000		0.000	0.49
$SUPTEC_{i1}$	0.024		0.034	0.70
$COMIMP_{i1}$	0.069		0.066	1.05
$PROIMP_i$	-0.085		0.061	-1.38
$MXMd_{i1}$	1.037	***	0.346	3.00
$MOD_i\times MXMd_{i1}$	-0.281	***	0.089	-3.15

Model Fit: $\chi^2(18)=179.02$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

Table 8-3. Explaining Product Performance Contract with Supplier B
in a System of Equations

DV: Product Performance Contract Specificity with Supplier B, $PPCSpec_{i2}$

Variable	Coef.		SE.	z
MT_i	0.136	***	0.044	3.05
$OEMTSI_{i2}$	0.222	*	0.117	1.90
$TECUNC_i$	-0.498	***	0.167	-2.99
$OEMTSI_{i2}\times TECUNC_i$	0.083	**	0.042	2.00
MOD_i	0.119		0.091	1.30
$TENURE_i$	-0.001		0.006	-0.22
$TRANSCOPE_i$	0.035		0.043	0.82
$COMPRAT_{i2}$	0.466		0.389	1.20
$LogOEMSIZE_i$	0.123	***	0.041	2.98
$LogSUPSIZE_{i2}$	0.007		0.038	0.17
$LogOEMSIZESUPSIZE_{2i}$	-0.010		0.007	-1.43
$FINFREQ_i$	0.000		0.000	-1.10
$NKEYCOMP_i$	0.000		0.000	0.02
$SUPTEC_{i2}$	0.059		0.037	1.60
$COMIMP_i$	0.059		0.052	1.15
$PROIMP_i$	-0.121	*	0.062	-1.95
$MXMd_{i2}$	1.028	***	0.390	2.64
$MOD_i\times MXMd_{i2}$	-0.268	***	0.103	-2.60

Model Fit: $\chi^2(18)=227.54$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

The estimation results of the transaction costs, i.e. equations (8-2) to (8-5), are presented in Table 8-4 to Table 8-7. As it is evident, the positive relationship of PPCSpec and M is observed in estimation of monitoring cost with both suppliers ($\beta_{41} = 0.226$, $p < 0.01$) and ($\beta_{51} = 0.206$, $p < 0.01$).

Table 8-4. Explaining Monitoring Cost with Supplier A in a System of Equations

DV: Log Monitoring Cost with Supplier A, $LogM'_{i1}$

Variable		Coef.		SE.	z
$PPCSpec_{i1}$	(β_{41})	0.226	***	0.035	6.53

Model Fit: $\chi^2(1)=42.59$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

Table 8-5. Explaining Monitoring Cost with Supplier B in a System of Equations

DV: Log Monitoring Cost with Supplier B, $LogM'_{i2}$

Variable		Coef.		SE.	z
$PPCSpec_{i2}$	(β_{51})	0.206	***	0.027	7.64

Model Fit: $\chi^2(1)=58.39$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

Table 8-6. Explaining Dispute Cost with Supplier A in a System of Equations

DV: Log Dispute Cost with Supplier A, $LogD'_{i1}$

Variable	Coef.		SE.	z
$PPCSpec_{i1}$	-0.014[13]		0.061	-0.23
$LogM'_{i1}$	1.338	***	0.124	10.78

Model Fit: $\chi^2(2)=130.94$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

Table 8-7. Explaining Dispute Cost with Supplier B in a System of Equations

DV: Log Dispute Cost with Supplier B, $LogD'_{i2}$

Variable	Coef.		SE.	z
$PPCSpec_{i2}$	-0.051		0.053	-0.97
$LogM'_{i2}$	1.248	***	0.133	9.38

Model Fit: $\chi^2(2)=100.14$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

[13] The negative relationship of PPCSpec and LogD' is not significant in Table 8-6 and Table 8-7. This could be because of the way the model is estimated. In Chapter Seven, I estimate dispute costs, using fixed effects of OEMs, i.e. OEM dummies in the right hand side of equation (7-5). However, it is not possible to add OEM dummies in the equation, as I use a cross section data including observations from supplier A and B.

Finally, results of the estimation of Product Enhancement Outputs are presented in Table 8-8. I find support to both H_9 (β_{11}= 0.384, $p < 0.05$) and H_{10} (β_{12}= -0.550, $p < 0.01$). Evidently, OEMs disputes with the supplier when there is a major component failure involved are not wasted costs entirely. OEM's disputes with the supplier when there is a major component failure are clearly correlated with the final product's enhancement outcomes, i.e. PE_Out. Moreover, OEMs disputes with a supplier when there is no major component failure involved continues to be wasteful possibly by wasting resources that otherwise could be used to enhance the product.

Next, there are other observations from the results that add to our understanding of the complex phenomena happening between industrial buyers and sellers. While OEMs can enjoy higher levels of PE_Out by drafting more specific contracts with supplier A, $PPCSpec_1$, (β_{15}=7.086, $p < 0.05$), they are not any better off if they do the same with supplier B, $PPCSpec_2$ (β_{19}=-7.906, $p < 0.05$).

Also, when there is no major component failure involved OEMs experience higher levels of PE_Out by exerting more monitoring effort, i.e. monitoring cost, LogM', (β_{14}=1.663, $p < 0.01$). On the contrary, more monitoring where there is a case of major component failure, does not add to OEMs' ability to enforce the contract, and as a result, the more monitoring cost, the less PE_Out, (β_{13}=-1.123, $p < 0.01$).

Table 8-8. Explaining Product Performance Outcomes in a System of Equations

DV: Product Performance Output, PE_Out_i					
Variable		**Coef.**		**SE.**	**z**
$LogD'_{i1}$	(β_{11})	0.384	**	0.167	2.30
$LogD'_{i2}$	(β_{12})	-0.550	***	0.192	-2.86
$LogM'_{i1}$	(β_{13})	-1.123	***	0.351	-3.20
$LogM'_{i2}$	(β_{14})	1.663	***	0.410	4.06
$PPCSpec_{i1}$	(β_{15})	7.086	**	2.961	2.39
$PPCSpec_{i1} \times MT_i$		-1.662	**	0.711	-2.34
$PPCSpec_{i1} \times DIFF_i$		-1.218	**	0.511	-2.39
$MT_i \times DIFF_i$		0.007		0.177	0.04
$PPCSpec_{i1} \times MT_i \times DIFF_i$		0.290	**	0.123	2.37
$PPCSpec_{i2}$	(β_{19})	-7.906	**	3.078	-2.57
$PPCSpec_{i2} \times MT_i$		1.789	**	0.725	2.47
$PPCSpec_{i2} \times DIFF_i$		1.379	**	0.534	2.58
$PPCSpec_{i2} \times MT_i \times DIFF_i$		-0.312	**	0.126	-2.49
MT_i		0.070		1.004	0.07

Model Fit: $\chi^2(14)=128.20$***
Estimation Method: 3SLS (N=172)
* p<0.1 ** p<0.05 *** p<0.01
Intercept not shown.

Chapter Nine Results and Discussion

Four main themes emerge from our results. First, multi-component systems characteristics are key shift parameters determining the efficiency of product performance contract specifications in OEM-supplier relations. Second, the emerging IoT technologies, specifically, component monitoring capabilities, sharply impact how supply chain partners organize their product performance exchanges. Third, I identify and calibrate the transaction costs that drive the efficiency calculus. Four, I unravel the mixed impact of ex-post transaction costs on performance. I discuss these and highlight our key theoretical and managerial contributions in the following paragraphs.

The testable hypotheses were premised on three broad underlying constructs relevant to the context - (1) the salience of the hold-up risks and the associated safeguarding incentives perceived by the OEM; (2) the transaction costs associated with the technological uncertainty in which the transactions are embedded; and (3) specific systems factors related to the spectrum of OEM's component mix and match choices, extent of component monitoring technology and the modularity of the OEM product. We find that the predictions largely survive the empirical tests with all key hypotheses explaining product performance contract specificity (H_1 to H_4) supported.

Monitoring technology is a particularly important variable that emerges here. On the one hand, these are non-trivial investments in a relatively new technology whose returns on investments are uncertain at best. On the other hand, these come with a promise of realizing greater productive value from the supplier relations. Our results suggest that part of this value derives from economizing on the ex-post monitoring efforts. Firms seem to endogenize the efficiency-enhancing capabilities of this technology as they specify their contracts. Indeed, companies with a low-cost positioning deploy the technology more extensively. Other cost considerations including hold-up risks and scale economies are also implicated.

A more compelling evidence of how product performance contracts add value to the OEM-supplier relations, come from our estimation of the empirical impact of contractual deviations from the estimated optimal specifications. The message is clear - badly designed contracts bleed value in transaction costs. In this, we illustrate the tightrope balancing inherent in the OEM-supplier interactions. How significant is the impact? Consider this - any marginal deviation from the optimal product performance contract specificity invites a transaction cost penalty of $e^{2.499}$ (using the significant β_2 coefficient from equation (7-4) reported in Table 7-1 panel (a)) which is about 12 man days. This is a significant number and indicative of the value of appropriate contractual specifications.[14]

We can further decompose the impact of misspecifications on the dispute, monitoring and contract writing costs. For ex-post disputes, the marginal impact of

[14] Note that the aggregate scale measure of contract specificity makes it difficult to pin down the marginal deviation to a grounded measure and in turn makes the marginal impacts only indicative. However, it is possible to calculate the relative impacts of over or under specifications with greater certainty.

under-specification is $e^{0.827} = 2.286$ compared to $e^{-0.827} = 0.734$ for the marginal over-specification - suggesting that the dispute *cost penalty for the marginal under-specification* is about 5 times ($e^{0.827}/ e^{-0.827}$) the *benefits of the marginal over-specification* (using the significant β_{11} coefficient from equation (7-5) reported in Table 7-1 panel (b)). Similarly, the *cost penalty for the marginal over-specification* outstrips the *benefits of the marginal under-specification* by 1.7 and 4.3 times, for the monitoring and contract writing costs respectively, (using the significant β_{21} and β_{31} coefficients from equations (7-6) and (7-7) reported in Table 7-1 panel (c & d)). This illustrates the tightrope balancing act required of the OEM-Supplier contracting. To the best of our knowledge, we are among the first to calibrate this trade-off.

Moreover, we find empirical evidence that our hypotheses on the role of ex-post disputes on product enhancement outcomes are supported H_9 and H_{10}, reported in Table 8-8. Based on this result, not every dispute negatively impacts the product performance. On the occasions that the OEM is hit by a major component failure, such ex-post disputes possibly act as a driver to improve products quality ($\beta_{11}= 0.384$, $p < 0.05$). The probable reason might be the substitute role of disputes in the presence of the contract. When the contracts are not as good as that they should be – based on the fact that $PPCSpec_{i1}$ has a positive association with PE_Out_i – then disputes substitute the governance form. Note that the positive relationship of $PPCSpec_{i1}$ with PE_Out_i, ($\beta_{15} = 7.089$, $p<0.05$), suggests more specific contracts end are associated with higher product enhancement outcomes.

Likewise, when the OEM and the supplier are not experiencing any major component failure, any disputes may erode product enhancement efforts by the OEM (β_{12}= -0.550, $p < 0.01$). Again the substitution of disputes and contracts is evidently present. When increasing the specificity level of the contract is not helping the OEM to achieve higher levels of product enhancement, (β_{19} = -7.906, $p<0.05$), then disputes are also negatively associated with product enhancement outcomes.

Chapter Ten Theoretical and Managerial Implications

Theoretical Contributions

The product spectrum around us is characterized by numerous multi-component systems. The nature of these products brings myriad interconnect and associated interoperability concerns. These concerns are particularly serious in industrial contexts where significant non-re-deployable resources are invested. Any dip in performance or quality can put such assets at risk, adversely affect productivity, and invite significant liability concerns. Since much of the challenges are faced by OEMs who put together multiple suppliers' components, they have a central role in managing the inter-organizational exchanges as a means to address those concerns. There is a small but growing body of literature that brings together these sensitivities into the realm of inter-organizational contracts and practices. Much of this body of work has looked at make or buy type of decisions in the context of MCS (Stremersch et al., 2003; Ghosh et al., 2006; Ghosh & John, 2009 etc.). However, the literature is mostly silent on the ex-post challenges that are salient in many of these organizational arrangements. In particular, there is not much guidance in the literature on how to manage the complexities of interconnect challenges that bedevil many of these situations. While Ray et al. (2016) approach the problem from a channel competition lens, we believe ours is a first attempt to frame this problem around transaction costs.

In the process, we believe we shed an important light into how product performance exchanges are managed in B2B settings. The warranty literature relevant here is largely developed around an agency theoretic view of the transactional arrangement (Soberman, 2003). More importantly, the scope of its inquiries is largely restricted to B2C transactions (Chu & Chintagunta, 2011). This leaves a large part of our economic spectrum, the B2B transactions, unaddressed. We would be among the first to address this domain, going beyond an information based agency theoretic narrative and illustrating the important role of transaction costs in managing product performance contracts.

Last but not the least, the current inter-organizational literature in TCE has delved in some detail into the antecedents and consequences of the ex-post adaptation processes and explicating how these create and extract value in the transactions. Some of these are efforts to calibrate the nature of the ex-post costs (Houston & Johnson, 2000; Antia & Frazier, 2001; Kashyap et al., 2012 etc.) while others attempt to incorporate the role of firm strategy and strategic capabilities (Ghosh & John, 2005; 2009). By illustrating the trade-offs between the different ex-post and ex-ante transaction costs and the critical role played by the capabilities derived from the emerging monitoring technologies, we contribute to both these streams.

There is a relatively large body of literature that looks at the relationship of the governance and performance variable exchange performance (Cannon et al., 2000), exchange relationship (Mooi & Gilliland, 2013; Poppo & Zenger, 2002; Susarla et al., 2009), exchange satisfaction (Jap & Ganesan, 2000; Poppo & Zenger, 2002), relationship satisfaction (Mesquita & Brush, 2008), production efficiency (Hoetker & Mellewigt, 2009), alliance performance (Ghosh & John, 2005; Sande & Haugland, 2015), and product enhancement and cost reduction (Ghosh & John, 2005; Sande & Haugland, 2015). However, to the best of my knowledge, this is the first study that looks at the impact of the outcomes of the governance form, i.e. transaction cost, on product performance. In the MCS context, where manufacturing the multi-component system is at the heart of the OEM's operation, the product performance is a good measure of firm performance. In this study, I identify that not only is there a clear link between governance form, i.e. product performance contract specificity, at the confluence of strategy and product monitoring capabilities, and product enhancement outcomes, but also there is a link between the realized transaction costs and product enhancement outcomes. Consistent with (Ghosh & John, 2009), I find support that business strategy moderates the relationship between governance form, and product enhancement outcomes. Still more, I find that monitoring technology has a moderating effect on governance form's impact on product enhancement outcome. I do not find any evidence that the product monitoring capability acts as a good predictor of performance. Furthermore, I shed light on the functional and dysfunctional effects of realized transaction costs on product performance, in the industrial buyer and seller relationship in the MCS context. I illustrate under what circumstances realized ex-post costs can be both functional and dysfunctional for the product enhancement efforts. When the OEM is caught up in a major component failure, the ex-post disputes take on a corrective form to balance the relationship with the supplier, to the end of enhancing the product performance. While the OEM could benefit from more specified contracts to achieve higher product performance, the ex-post disputes act as governance tool to find a solution for the major component failure crisis. The more disputes are associated with higher product enhancement outcomes. This could be because, in the absence of any other regulating mechanisms, disputes help both the OEM and the supplier to come to a common understanding on desired performance outcomes. At the same time, any further contract monitoring abrades product performance. This could be because firm's efforts are wasted on mentoring where there is no need for further contract monitoring, taking away the valuable resources that could be used to fine tune and enhance the product. In a contrasting situation, when there is no major component failure involved, the OEM does not benefit from more specific contracts. This could be because the existing arrangements with the parties are good enough to attain the desired performance goals. In this situation, ex-post contract monitoring cost is a well-spent cost. The more contract monitoring is associated with higher product enhancement outcomes. It could be because the OEM can access a wealth of operating data which enables the OEM to do preventive or corrective actions in time. On the other hand, any increase in the disputes levels with the supplier proves to be dysfunctional. The reason could be such disputes take away valuable resources in the firm, where such resources could be used more meaningfully somewhere else to improve performance.

Managerial Implications

Managers intuitively recognize the significant transaction costs involved in managing contracts. Industry leaders like General Electric appoint Contract Performance Managers for key accounts across several of its business units in Aviation, Power, Oil and Energy etc. Companies like Coreworx offer customized contract management software specifically designed for the purpose. Nevertheless, efforts to manage these transaction costs can be short sighted. Often the significant ex-ante commitments come in the way of specifying the contracts in greater details. Managers must take into account the potentially high penalty that might accrue in the form of ex-post disputes in such cases. Indeed, our results show that the marginal impact of under-specification is at least 5 times that of the benefits of over-specification.

The evolution from detail based specifications to performance based contracting has in more recent times been accompanied by advanced component monitoring capabilities at the core of the emerging IoT technologies. While these offer unprecedented performance monitoring capabilities, managers would be advised to recognize that it is not without cost. Lower monitoring costs lead to greater monitoring, which generates more disputes as more fault lines are recognized. The results thus provide empirical support to the anecdotal evidence we have witnessed in the field study. This statement by a Contract Performance Manager statement specifically resonate with our findings -- "*Monitoring costs are high for 'leakage' type of costs. ... This is where most of the disputing takes place.*"

Managers should therefore exercise caution in deciding their level of investments in such technologies and keep in mind that an accurate assessment of the returns on these investments must also carefully consider the *other* value generating potential. Some of these might require a rethink to new business models. A case in point is Bosch Rexroth's "Trended Condition Monitoring" systems and the associated menu of Maintenance Service contracts. Bosch's service offer maps to a graded scale - from reactive to proactive service engagements. Where they install the monitoring equipment, they match the greater monitoring abilities to more comprehensive predictive maintenance schedules - thereby folding the potentially high bilateral transaction costs into more internal administrative processes.

Managers should also recognize that multi-component systems bring unique challenges that transcend the usual technical interconnect concerns. Industry-wide compatibility standards notwithstanding, inter-brand component mix and match is fraught with unforeseen complexities. Managing these is rarely a matter of simply adhering to technical protocols or well-specified contracts. OEM-supplier relations can and will benefit from more investments in relational processes that reduce the salience of disputes.

Finally, managers should be able to tell apart when realized transaction costs are functional or dysfunctional. This is to suggest that not every form of transaction cost necessarily hurts business performance. In the context of MCS where component failure is a reality of life such distinction is of utmost importance for the managers. In circumstances where there is a major component failure, the managers obviously do not have the luxury going back in time and define a more specific contract to avoid circumstances leading to the major component failure. The more realistic tool at hand is the pointed disputes with the suppliers. The higher disputes in such circumstances are associated with higher product enhancement outcomes. In circumstances, that the governance form is not well designed and there is a major point of contention in the relationship over the product performance, such disputes can kick in as a substitute governance tool to align the buyer and the seller to achieve higher product performance. The other key recommendation to managers is related to the situation where there is no major component failure. In such circumstances, managers are better off by spending more effort on contract monitoring than any disputes with the suppliers. Strict adherence to the mutually agreed terms and condition, under robust contract monitoring system, is a better predictor of product performance. In such less than critical occasions, disputes continue to act as dead weight losses. They consume the OEM's resources while they could be used meaningfully in product enhancement domain otherwise.

Chapter Eleven Limitations and Future Work

To fathom the nuances of the MCS domain, there is a need for significant efforts, not all of it theoretical. The empirical challenges of researching industrial contexts are roughly proportional to the granularity with which the research questions investigate efficiency and value addition in business relationships. Given that such relationships are often at the heart of the firms' competitive advantage, they are generally unwilling to share relevant data. That said, we must continue to ask the difficult questions and make our best efforts to address them despite the constraints.

Particularly, one of the major limitations of this study is the lack of data on the product monitoring technology investments. Without clear information on the monetary levels of the investments in such technologies, it is not possible to calculate the return on investments on such technologies with great certainty. One stream of future work from this study is to calibrate the impact of such IoT based technologies on product performance, given the initial investments.

Another implication of data scarcity and difficulty of accessing private data in this study is that I have collected data from one side of the relationship. Ability to collect data from both industrial buyers and sellers over key component transactions could shed more light on the nuances of the complex relationships in the MCS settings.

A plausible extension of this work is in the domain of studying the OEM's downstream relationships given the upstream arrangement with the suppliers. Product related performance measures are not the only target to hit for the OEMs in the multi-component system industries. The effectiveness of the downstream arrangements with the retailers and the wholesalers is partially determined by the governance mechanisms at the upstream of sourcing the key components. Additionally, the notion of product performance is also relevant in the relationship of the OEM and distribution channel members, in the form of manufacturer warranties. There are two important areas of inquiry here: First, how does a peripheral marketing mix elements such as product warranty is affected by the availability of product monitoring data?, and second, how does the OEM choose to arrange its relationship with the downstream channel members both in the presence of product usage data?

Yet another extension of this work can look at how product monitoring data is enabling new business models in the form of component warranties which are administered by the component supplier and the user or the distributor. This line of research will look at the incentives of the OEM to monopolize or sharing the product monitoring data with the suppliers and distributors.

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Chapter Thirteen Appendix A

Questionnaire

All the questionnaire items are reported in this Appendix.

Construct Definition, Sources, and Instruction to Respondents	**Items**	**Standardized Loadings**
Product Performance Contract Specificity (PPCSpec) 5 questions- Cronbach's Alpha 0.829, CFI=0.842, AVE=0.598 Not Specified at all (1) - Very Specified (7)	How specified is your contract with each supplier with respect to the component design specification?	0.703
	How specified is your contract with each supplier with respect to the component performance requirement?	0.800
	How specified is your contract each supplier with respect to the delivery schedule?	0.802
	How specified is your contract with each supplier with respect to the component price?	0.776
	How specified is your contract with each supplier with respect to the dispute resolution?	0.780
Contract Disputation (D) 1 question	In number of man-days, how much time did you and your colleagues, including company lawyers, spend on disputing with each supplier over departure from a desired performance or a component failure?	
Contract Monitoring Cost (M)	How many man-days have you and your colleagues collectively	

1 question	spent to monitor the contract with each supplier, within 3 months after the component delivery?	
Contract Writing Cost (W) 1 question	In number of man-days, how much time did you and your colleagues, including company lawyers for example, spend on negotiating and drafting the agreement with each supplier?	
Extent of Monitoring Technology (MT) 8 questions - Cronbach's Alpha 0.949, CFI= 0.848, AVE=0.740 Monitoring data: Some products are equipped with capabilities to sense, record, and transmit data related to the performance and general health of the product and/or its associated components. For example, many Engine Control Units (ECU) have capabilities to generate data about the performance of the engine and its components. This data is normally available at the time of service but is also sometimes fed real-time to monitoring and diagnostic centers. The OEM or the suppliers may have remote access to the data. We call these monitoring data, and it is usually used to diagnose a performance failure or predict a possible failure event. Please respond to the following questions relating to the use of such technology in your business, where your product is in use by the end-user. Strongly Disagree (1) – Strongly Agree (7)	We have the capability to sense and record such monitoring data.	0.877
	It is easy for us to access such monitoring data.	0.925
	We have real time access to such monitoring data.	0.885
	Supplier has access to such monitoring data.	0.716
	The monitoring data allows us to clearly diagnose the cause of a performance failure of the product.	0.907
	The monitoring data allows us to predict and respond before a performance failure occurs.	0.896
	We usually share such monitoring data with our suppliers.	0.817
	It is common for our suppliers to share such monitoring data with us.	0.840
OEM's Transaction Specific Investments	We have made significant investment in tools and equipment dedicated to the relationship with	0.853

(OEMTSI) 6 questions - Cronbach's Alpha 0.834, CFI=0.929, AVE=0.556 Measurement Adopted from (Ghosh & John, 2009)– 6 Questions Strongly Disagree (1) – Strongly Agree (7)	this supplier.	
	We have spent significant resources designing the specifications for this item(s) to ensure that it fits well with the supplier's production capabilities.	0.844
	The procedures and routines we have developed to obtain this item(s) are tailored to this particular item from this supplier.	0.781
	This supplier has some unusual technological norms and standards which have required extensive adaptation on our part.	0.707
	Most of the training that our people have undertaken related to this supplier's item(s) would be of little value in dealing with another supplier.	0.444
	Training this supplier's people has involved substantial commitment of time and money.	0.769
Technological Uncertainty (TECUNC) 3 questions - Cronbach's Alpha 0.632, CFI=1.000, AVE=0.607 Measurement Adopted from (Ghosh & John, 2009) - 3 questions Strongly Disagree (1) – Strongly Agree (7) (reversed) The following statements are about your end product technology. Please select the most appropriate choice in each sentence for each supplier.	Accepted standards for the end product design and specifications exist.	0.858
	Industry standards for the end product performance specifications are very predictable.	0.854
	Competitors' end products are similar to our end product.	0.597
Modularity (MOD) 3 questions - Cronbach's Alpha 0.553, CFI=0.918, AVE=0.542 Measurement Adapted from (Ghosh et	The composition of our product can be easily altered without triggering compatibility concerns.	0.843
	The configuration of our product is based on standard interfaces.	0.458
	The composition of our product is	---

al., 2006) – 3 questions Strongly Disagree (1) – Strongly Agree (7) Note1: To improve reliability and validity of the results, this item is dropped. The significance of the results does not change after dropping.	perfectly modular.*	
	Certain aspects of our product configuration can be easily replaced with similar configurations from another manufacturer without raising compatibility issues.	0.841
Mixing and matching (MXM)[15] 1 question	How many constraints has each supplier imposed over combining its component with other brands? Many (1) – None(7)	
Low cost strategy (LC) 1 question	Our target market values us because we provide a product at a low cost.	
Differentiation Strategy (DIFF) 3 questions – Cronbach's Alpha 0.653, CFI=1.000, AVE=0.592 Strongly Disagree (1) – Strongly Agree (7)	Our target market values us because we provide a differentiated product.	0.826
	In our company, we know how to deliver our value proposition to our customers.	0.648
	Our customers are willing to pay premium prices for our product.	0.820
OEM Integrative Resources (INTRES) 5 questions – Cronbach's Alpha 0.870, CFI=0.934, AVE=0.663 Strongly Disagree (1) – Strongly Agree (7)	We have in place procedures to involve marketing and technical personnel in product development.	0.714
	We have set-up procedures to co-opt with our suppliers in designing the best solutions for our customer's needs.	0.792
	We have cross-functional teams to enable the translation of customer needs into product features.	0.872

[15] Dummy Variable - 1 if no constraint else 0

	We have instituted policies to permit timely adaptation of our product configuration to customer needs.	0.845
	We have set-up a knowledge system to transfer our experience from one customer context to another.	0.837
Number of Key Components (NKEYCOM) 1 question	How many key components are there in your product?	
Number of Potential Component Supplier (NPOTSUP) 1 question	What is the number of potential suppliers for each component?	
Proprietary Technology of the Supplier (SUPTEC) 2 questions - Cronbach's Alpha 0.871, CFI=1.000, AVE=0.885 Strongly Disagree (1) – Strongly Agree (7)	The supplier is using proprietary patented technologies to manufacture its component:	0.941
	The supplier has patented different aspects of the component.	0.941
Supplier's Transaction Specific Investments – (SUPTSI) 5 questions - Cronbach's Alpha 0.907, CFI=0.971, AVE=0.732 Measurement Adopted from (Ghosh & John, 2009)– 6 Questions	This supplier has made significant investment in specialized tools and equipment dedicated to the relationship with us.	0.881
	This supplier has spent significant resources designing the specifications of the component to ensure that it fits well with our production capabilities.	0.895

Strongly Disagree (1) – Strongly Agree (7)	Our supplier has tailored its procedures and routines for delivery of the component to us.	0.846
	We have some unusual technological norms and standards which have required extensive adaptation on the part of this supplier.	0.819
	Training their employees to deal with our company has involved substantial commitments of time and money on the part of this supplier.	0.832
Tenure of the Relationship (TENURE) 1 question	How long have you had business relationship with each supplier in years?	
Scope of the contract (TRANSCOPE) Measurement Adapted and further developed from (Mooi & Ghosh, 2010)- 1 question What has the suppliers committed to deliver in this contract in addition to supplying the component? (Respondents can choose multiple options – Formative Scale)	Component	
	Development of a New Design of the Component	
	Component Performance Guarantee	
	Training	
	Assembly of the Component on your Product	
	Documentation	
	Technical Support	
	Technical Support to the end user	
	Warranty to the OEM	
	Warranty to the end user	
	Consulting	
Component to Product Price Ratio (COMRAT) 1 Question	What is the price ratio of each component to the product? (Divide the buying price of each component to the average selling price of your product.)	

OEM (LOGOEMSIZE) and Supplier Size (LOGSUPSIZE) 2 questions	Please answer the following to the best of your knowledge. 1. What is your company's most recent annual sales revenue? (in Million USD) 2. What was the size of the supplier A and B in sales revenue (per annum) in MILLION USD last year?	
Transaction Frequency (TRANFREQ) 1 question Much less Frequent (1) – Much More Frequent(7)	How frequently have you done business with each supplier in the past 12 months, in comparison with the average supplier?	
Financial Transaction Frequency (FINFREQ) 1 question	How many times have you conducted financial transactions with each supplier in the past one year? Please specify.	
Component Importance (COMIMP) 2 questions – Cronbach's Alpha 0.615, CFI=1.000, AVE=0.740 Not Important at All (1) – Very Important (7)	How important is each component in overall system performance?	0.860
	How important is each component to the profitability of your company?	0.860
Product Importance (PROIMP) 1 question Not Important at All (1) – Very Important (7)	How important is the product to the profitability of your company?	
Unpredictability of Innovation (UNPINN) 1 question	It is difficult to predict when new innovation will hit the industry.	

Strongly Disagree (1) – Strongly Agree (7)		
Product Enhancement Outcomes (PE_Out) The way we are managing our relationship with our suppliers has led us to: 8 questions – Cronbach's Alpha 0.870, CFI=0.897, AVE=0.573 Strongly Disagree (1) – Strongly Agree (7)	Manufacturing a high performing product that outperforms the competitors.	0.828
	Improving our product quality.	0.790
	Decreasing the cost of product performance failures.	0.693
	Creating higher value for our customers than our competitors.	0.790
	Delivering a product that creates an edge for the end-users.	0.729
	Finding solutions for product performance failure cases more efficiently.	0.740
	Selling a highly differentiated product compared to that of our competitors.	0.724
Customer Heterogeneity (HET) 3 questions – Cronbach's Alpha 0.742, CFI=1.000, AVE=0.772 Strongly Disagree (1) – Strongly Agree (7)	Our product buyers have very similar pricing needs.	0.556
	Our product buyers have very similar needs for quality.	0.715
	Our product buyers have very similar technical needs.	0.721

Chapter Fourteen Appendix B

Common Method Bias

Harman's One Factor Test:

To assess CMB, I use Harman's One-Factor test at the first step ("Defense Standardization Program: Performance Specification Guide," 1995). We try to show that whether one factor can explain all of the variance data. The unrotated confirmatory factor analysis with measurement items of multi item variables such as MT, PPCSpec, OEMTSI, TECUNC, MOD, DIFF, INTRES, SUPTEC, SUPTSI, and P_out with only one factor results in a factor that is not capable of explaining the majority of variance in data. The proportion of the factor is 0.395 which is below 0.5. Therefore, the majority of the variation is not explained by just factor.

Common Latent Factor

In the next step, we use the recommended method illustrated by (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). While this method can be used to control for common method bias in structural equation modeling, in case there is high level of common method bias, it can also be used to diagnose the level of common method bias. We set up a measurement model using all multi item composite variables that we have used in Harman's one factor test. Then we add a common latent factor with loadings to all items, with a constraint loading of ‘a’. The goal is to estimate the constraint loading of ‘a’. The estimated loading of the common latent factor on measurement items is 0.083. This translates to $0.083^2=0.006889$, or 0.7% of variance in our measurement explained by the common latent factor. The explained portion of the variation by the common latent factor is very minimal. There is no specific threshold in the literature to comply with other than 50%, and 0.7% already seems very low. Figure 14-1. Measurement Model with Common Latent Factor (CLF) illustrates the measurement model set up.

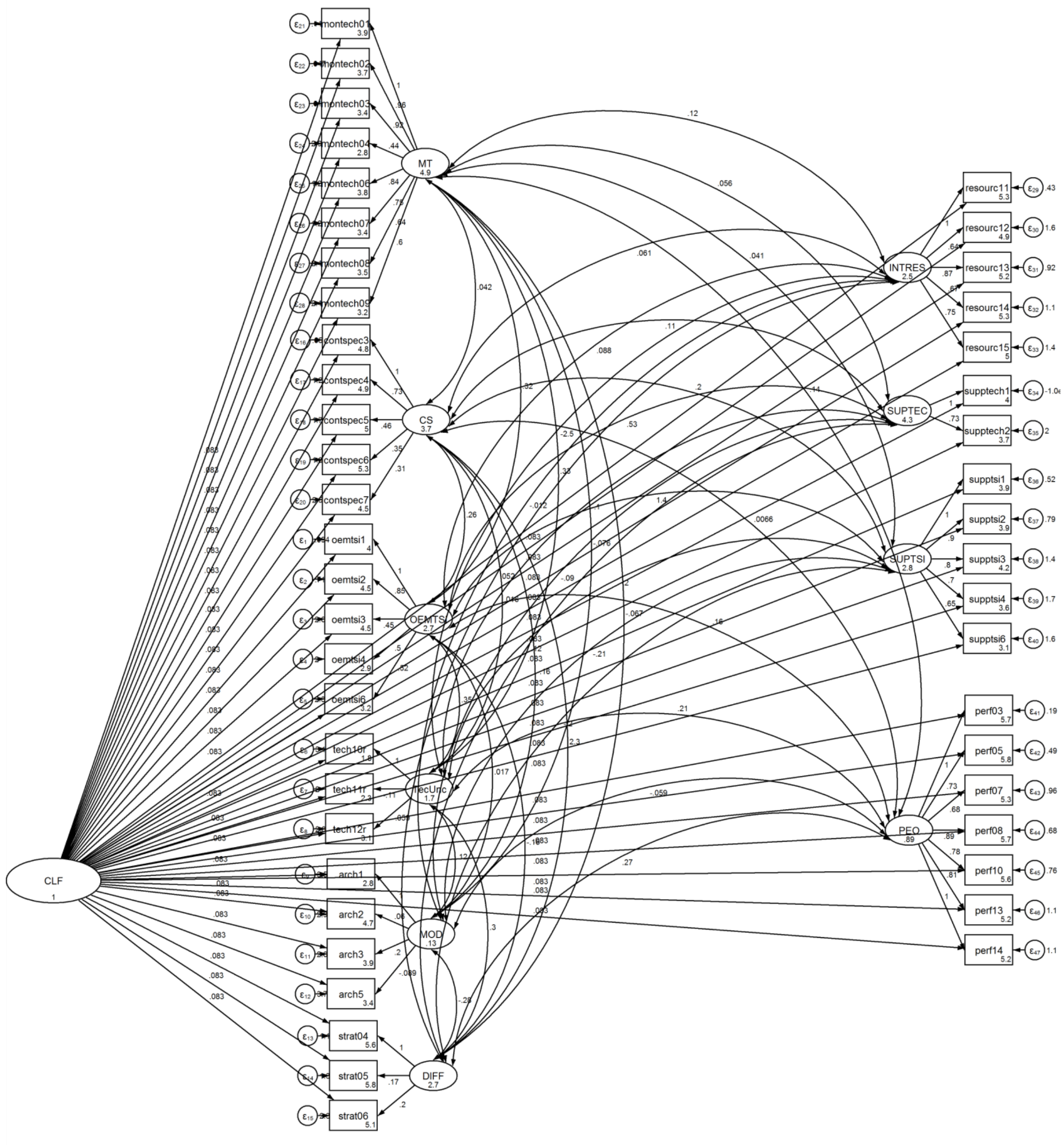

Figure 14-1. Measurement Model with Common Latent Factor (CLF)

Marker Variable

The other test to assess common method bias is the addition of a marker variable (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The idea is to add a variable which does not have any conceptual correlation with other composite variable. The variable we add to the model is customer heterogeneity or HET. After adding the marker variable, we estimate the impact of common latent factor on all variables again. The loading of the common latent factor on all measurement items is constrained to a similar value. The estimated loading is 0.079. This translates to $0.079^2 = 0.006241$, or 0.6% of variance in our measurement explained by the common latent factor. Since the explained portion of variance by the common latent factor is 0.6% after inclusion of the marker variable, and it seems negligible, we claim that there is no major concern with common method bias.

The explained portion of the variation has decreased after addition of the marker variable. Had it increased while we introduce the marker variable, there was a higher possibility of common method bias as the source of this variation increase.

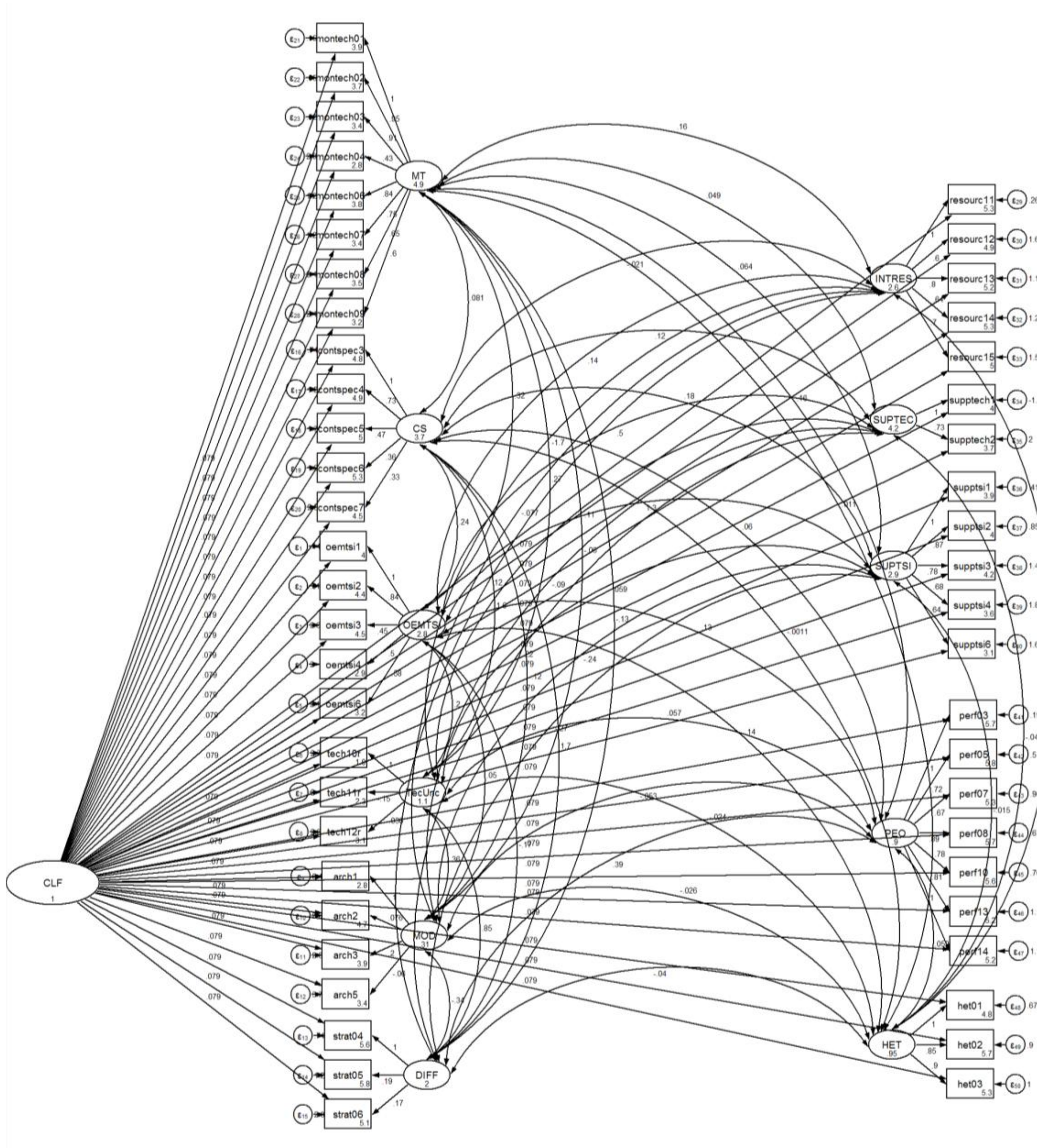

Figure 14-2. Measurement Model with Common Latent Factor (CLF) and Marker Variable

Figure 14-2 illustrates the measurement model after the inclusion of the marker variable. Note that the impact of the CLF in measurement model with the marker variable is constrained. The constrained parameter is identified by ‘a’; however, the values differ when there is a marker variable, in comparison with Figure 14-1 that there is no marker variable, as it is explained above.