Working Title: Trust and Investment - An Empirical Assessment

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Abstract

We develop a simple model of contractual structures involving upstream suppliers and downstream producers. Using a unique dataset collected during a two year survey of the German automotive industry, we use the model to study the effects and determinants of trust between automotive producers and their upstream suppliers. In contrast to the literature on trust we observe numerous dimensions of individual relationships. We develop and analyze different measures of trust and show that higher levels of trust mitigate underinvestment in a classical holdup situation. In particular, we demonstrate that the choice of procurement strategy is related to trust levels.

1 Introduction

1.1 Motivation

In the last couple of years, the automotive sector, one of the most innovative and important industries in most developed countries, has witnessed unprecedented turbulence. In June 2009 General Motors, the second biggest carmaker in the world, filed for chapter 11 bankruptcy proceedings. It appears that the former industry juggernaut has been strangled by mounting pension obligations, undermined by rising fuel-costs and outmanouvered by more innovative and design-savvy competitors. Since then, the financial crisis has made consumers even more loth to make extensive investments into their mobility. Governments throughout the world have responded decisively and expensively, propping up ailing carmakers by guaranteeing loans and providing liquidity on the one hand, and giving consumers additional incentives to replace their old cars through variations of the "cash for clunkers" program. Increasingly harsh competition for a slowing demand has eroded industry margins, placing an ever greater premium on companies that produce efficiently and are able to differentiate themselves from others through innovative products.

As a result of outsourcing efforts, carmakers contribute only minor shares of innovation efforts and the total value added of their product - in many cases they are reduced almost reduced to pure assemblers. Upstream suppliers are responsible for most groundbreaking basic research, which is then adapted to the specific needs of individual car models. The future success and chance of survival of carmakers more than ever depends on successfully managing their supplier-relationships and harnessing their innovative potential. Yet, there is an inherent conflict between this goal and rent-extraction/profit generation.

This nexus has garnered attention from researchers in the past. We hope to contribute a new perspective by looking at these relationships through the lens of *trust*. There have been significant advances in economists' understanding of trust in the past decade, which we discuss in the literature review below, but they share a major drawback: Both experiments as well as empirical approaches focus on subjects, investigating their general attitudes towards others ("Do you think in general others can be trusted?") or analyzing their willingness to contribute funds to more or less anonymous players in lab settings. A colloquial reading of the term trust, on the other hand, would tend to be based on the characteristics of the other person (trustworthiness), on the compatibility with own characteristics and preferences (do I find another person's smile comforting or disturbing?) or on details of the history of the relationship (has the other person cheated on me in the past?).

We are able to approach the subject of trust in a way that resembles these intuitive definitions more closely, using a unique data-set, collected from a online-survey of suppliers and manufacturers in the German automotive industry in 2007-2008. Our measures of trust are relationship-specific and we analyze the determinants of suppliers' trust in the manufacturer by linking them to reported past behavior. In the final step, we then focus on how trust is associated with different procurement strategies and how it affects relationship-specific investment by suppliers, which entails the aforementioned drastic consequences for future competitiveness.

The remainder of the article is organized as follows. After briefly outlining the related literature, we develop a very simple model in Section 2, from which we derive hypotheses on the effects of trust on supplier-relationships. In Section 3, we first introduce the study that provided the data on which we base our empirical investigation, an in-depth survey investigation into the structure of the German automotive industry. We present potential measures of trust and try to carefully evaluate what they capture. At the center of our empirical analysis, we analyze how trust between manufacturers and suppliers is related to two important questions: Sourcing decisions and Supplier (under-)investment. Finally, Section 4 concludes and raises some new research questions resulting from our findings.

1.2 Related Literature and Contribution

Interactions between suppliers and OEMs in the automobile industry are notoriously complex, fraught with moral hazard and hold-up problems. Nevertheless, both parties regularly invest substantial amounts of time, know-how and money into specific relationships. Apparent puzzles like this have piqued the interest of economists for quite some time - perhaps the most prominent explanation approaches can be subsumed under the headings of property rights theory (for hold up problems) or contract theory (for asymmetric information and moral hazard).[1] Beyond that, it has been well established that

[1]Due to the different focus of our study, we refer to the seminal Hart and Moore (1988), Grossman and Hart (1986) and Hart and Moore (1990), as well as the more recent Hart and Moore (2007) and

in settings like these, relational (or informal) contracts can play an important role in governing relationships. As opposed to formal contracts, which are linked to outcomes verifiable by third parties and courts, the term relational contract refers to *self-enforcing*, often implicit agreements "sealed with a handshake".

There is a rich theory on relational contracting in different contexts,[2] beginning with Bull (1987) who provides the original repeated games-framework for employment relationships. Also for employment, Baker, Gibbons, and Murphy (1994) demonstrate how the combination of formal and relational contracts can lead to better results than either instrument could achieve alone. Interestingly, there can be a substitutive (if either works almost perfectly) or complementary relationship between the two. In Baker, Gibbons, and Murphy (1999), the authors analyze the informal delegation of decision rights within hierarchies under different informational settings.

More recently, research has focused on more generic settings, searching for optimal contract design. Levin (2003) finds that while under moral hazard optimal relational contracts exist and are relatively simple, under hidden information cases arise under which agents do not respond to the incentives provided therein at all. Calzolari and Spagnolo (2009) further extend this scenario: The relationship between a principle and an agent interacting repeatedly can suffer from both moral hazard and hidden information - but the principal has a further tool available to him by being able to select from various competing agents (screening), who are able to collude. They find the intuitively appealing result that in cases in which non-contractible factors contribute more to the principal's payoff, the best package of instruments will rely more heavily on relational contracts with a smaller set of agents. Vice versa, in "simpler" settings in which the most important issues are contractible, the principal will rely on a more competitive setting amongst agents. We derive very similar results from our reduced-form static model in our analytical framework. Brown, Falk, and Fehr (2004) carry out an experimental study in order to be able to control for the level of enforceability of contracts. They find that as enforcement becomes more effective, the original long-term rent-sharing relationships are replaced with short-term arms-length agreements, very much in line with the theoretical results described above. This can be taken as evidence of a substitutive

Hart (2008), the latter two with many further references.

[2]We refer to MacLeod2007 for a careful survey on the literature of relational contracting, with a special focus on the effects of the quality of legals systems.

relationship between formal and relational contracts in their specific setting.

Entering into a business relationship without being able to resort to legal means of enforcement would probably be called a form of **"trust"** colloquially. This concept has for some time drawn considerable attention and scrutiny from experimental economists.[3] Yet researchers in applied microeconomics and IO have been cautious about using this term, even actively trying to avoid it (see, e.g. the discussion in MacLeod (2007)).[4] On the other hand, empirical researchers in the areas of macroeconomics and growth have been less reticent in this regard, so that some empirical strategies do already exist.

As a basis for many studies, the answers to the following question from the World Values Survey has been used: "Generally speaking, would you say that most people can be trusted or that you have to be very careful in dealing with people?" While one may doubt the power of this construct at first glance,[5] there have been some interesting results. The basic hypothesis of La Porta, de Silanes, Shleifer, and Vishny (1997) is that trust is an integral requirement for the functioning of larger organizations, in which the likelihood of repeated interactions is relatively small and thereby the established mechanisms for ensuring cooperative behavior are less effective. In a cross-country study they try to establish that populations in which higher levels of trust are prevalent should foster more effective governance as well as relatively larger firms. Aghion, Algan, Cahuc, and Shleifer (2008) perform an international comparative study in which they scrutinize the connection between levels of social capital (or trust/distrust) in populations with the amount of existing state regulation as well as the demand for it. The basic intuition is that a lack of civic mindedness in one's fellow citizens may lead to a stronger desire for the state to regulate interactions. They find very strong evidence for this, even for societies in which the government itself is plagued by corruption. Therefore it appears that trust and regulations are to some extent substitutes. In contrast to most other articles cited so far, Butler, Giuliano, and Guiso (2009) study the effects of trust on individual's economic outcomes instead of aggregate economic performance. They use the European Social Survey as well as experimental evidence to argue that a medium amount of trust may be optimal for individuals: With too little trust, too many opportunities for beneficial

[3]See Fehr (2009) for a sweeping overview of the experimental and neuro-economic literature.

[4]For a careful survey of the development of the term "culture" in economics and the effects of culture on economic outcomes, see Guiso, Sapienza, and Zingales (2006).

[5]See Sapienza, Toldra, and Zingales (2007) for an experimental study on the merits of this measure and a discussion of the previous literature.

interactions are missed, with too much trust the danger of being taken advantage of becomes too great.

Guiso, Sapienza, and Zingales (2009) use a slightly more concrete measure, the trust that citizens of a given country in Europe have for citizens of another. They find that the levels of trust are explained in part by characteristics such as the distance between countries, but also by factors such as sociological and genetic closeness and common history. They find that less trust in the citizens of a country is associated to significantly lower aggregate trade and investment. In a second study, Guiso, Sapienza, and Zingales (2004) suggest that the different characteristics of Italian regions lead their citizens to develop different levels of social capital. They then show that in high social capital/trust areas people are more prone to invest in stocks instead of holding cash reserves and have easier access to bank credit. The effect is mitigated by levels of education. Along similar lines, Guiso, Sapienza, and Zingales (2005) find that individuals who display higher levels of trust buy more risky assets relative to their wealth. They counter a common criticism by controlling for risk- and ambiguity-aversion, which does not make their original result disappear.

Finally, Bottazzi, Da Rin, and Hellmann (2009) study the willingness of venture capitalists to perform non-contractible services in a micro-economic environment. In particular, they analyze the influence of more effective legal systems in this context. Both in their theoretical model and their empirical analysis of a data-set with European venture-capital deals they find that a more efficient legal system has two effects. On the one hand it is complementary to trust, in the sense that it makes venture capitalists more willing to grant non-contractible support; but on the other hand, they require more protection for the case of failure of the venture.[6]

2 Analytical Framework

We consider the simplest possible model as a framework for the empirical analysis. To demonstrate the central tradeoff we are interested in, we study two potential procurement contracts.

We refer to the first type of contract as **Case I**. Here, in $t = 0$ the OEM picks

[6] In the working paper on the same data, Bottazzi, Da Rin, and Hellmann (2007) also show that higher scores on the Eurobarameter measure of trust between nations are associated with higher investments.

an individual supplier i, whose intrinsic quality θ_i is unknown to both parties at this point. One reason for this could be that the suitability of a given supplier only becomes clear in the process of the product specification. Alternatively we could also assume that θ_i is only known to i. After the OEM's irreversible[7] choice of i, θ_i is drawn from a distribution $Q(\theta)$ which is continuously increasing within the domain $[0, 1]$ and revealed to the supplier. Then, the supplier chooses an effort level I_i, e.g. designing the product under consideration, in the course of which he incurs the effort costs $c(I_i)$. We assume that both c' and c'' are strictly positive. In $t = 1$, the supplier's quality and investment choice become common knowledge. Then, in $t = 2$, the OEM and the supplier bargain about how to share the joint surplus from production, which we denote as $v(\theta_i, I_i)$, which is strictly increasing both in θ_i and in I_i. In this bargaining process, we denote the OEM's outside option as g and the supplier's outside option as $f(\theta, I)$. Clearly then, the first best investment level is determined by the first order condition $v_2 = c'$. We will call any level of investment below the first best *underinvestment*.

Within **Case I**, we distinguish two polar subcases with respect to the bargaining situation. In the first, which we call **subcase a)**, the OEM has the entire bargaining power and is in the position to make a take it or leave it offer to the supplier. In the second, **subcase b)**, the roles are reversed and the supplier makes a take it or leave it offer to the OEM.

In the second type of procurement contract, which we call **Case II**, the OEM attempts to induce competition in the design phase of the procurement process in the following way: At $t = 0$, he chooses n ex ante identical suppliers from a population that is "large enough", so that it imposes no upper bound on n. Each supplier chosen invests effort I_i upon learning his respective type θ_i. The types are each drawn from $Q(\theta)$. After these investments are sunk, a second price procurement auction is run (or equivalently, the suppliers engage in Bertrand competition) in $t = 1$. The winner of this auction then enters into bargaining with the OEM on how to share the joint surplus from production. As above we can distinguish the two polar subcases a) and b) regarding the distribution of bargaining power. In the following, we specify our assumption and then make the timing of the game and information structure completely explicit for each of the cases.

[7]Imagine that the interfaces between the part in question and the other parts have been designed.

2.1 Assumptions

Apart from the structure of the game as described, we make the following assumptions:
A1: $f(\theta, I) < v(\theta, I)$ and $\frac{\partial f(\theta,I)}{\partial I} < \frac{\partial v(\theta,I)}{\partial I}$ for any given (θ, I).

This assumption implies that the surplus generated from the supplier's investment within the relationship is always greater than the surplus obtained from that investment outside the relationship. Further, an increase in investment by the supplier leads to a greater creation of value within than outside the relationship.

A2: $v(\theta, I) - f(\theta, I)) > v(\theta', I) - f(\theta', I)$ if $\theta > \theta'$.

Higher quality suppliers generate a larger surplus above their outside option than lower quality suppliers for a given level of investment.

A3: $v(\theta, I) > v(\theta', I') \Rightarrow v(\theta, I) - f(\theta, I)) > v(\theta', I') - f(\theta', I')$

The higher the total surplus within a relationship, the higher is the efficiency loss suffered if bargaining breaks down. This implies that a supplier with a lower intrinsic quality θ can overcome this disadvantage to become more efficient through higher initial investment I.

2.2 Timing of the Game

Case I

t=0: First the OEM picks a supplier i. Then, θ_i is drawn from a continuous, increasing distribution $Q(\theta)$ with full support $[0, 1]$ and revealed to the supplier. Finally, the supplier chooses his investment level I_i and incurs the costs $c(I_i)$.

t=1: θ_i becomes public information and the supplier is awarded the production contract automatically.

t=2: The OEM and the supplier engage in bargaining. In case a) the OEM makes a take it or leave it offer, in case b) the supplier makes a take it or leave it offer. Then, the joint revenues $v(\theta_i, I_i)$ are produced and shared according to the bargaining outcome.

Case II

t=0: First the OEM picks a number n of suppliers. Then, for each supplier that has been picked, θ_i is drawn from the distribution $Q(\theta)$ and privately revealed. Finally, each supplier chooses an investment level I_i and incurs the costs $c(I_i)$.

t=1: θ_i becomes public information and suppliers engage in Bertrand competition (or equivalently a second price auction) for the production contract under perfect information.

t=2: The OEM and the supplier i who has placed the winning bid engage in bargaining. Again, the cases a) and b) above can be distinguished. Finally, the joint revenues $v(\theta_i, I_i)$ are produced and shared according to the bargaining outcome.

2.3 Results

We solve for a subgame-perfect equilibrium by backward induction for each of the cases.

Case I a) Sequence of contracts, OEM makes tioli-offer in period $t = 2$

In $t = 2$, the OEM offers the supplier a fixed payment T_2, maximizing $v(\theta_i, I_i) - T_2$. Hereby, he has to take the supplier's participation constraint $T_2 \geq f(\theta_i, I_i)$ into account, where f denotes the supplier's outside option. As the OEM has the entire bargaining power, he will choose $T_2 = f(\theta_i, I_i)$. This gives the supplier the following maximization problem in $t = 0$: $max_I f(\theta_i, I_i) - c(I_i)$, leading to the first order condition $f_2 = c'$. By **A1** the supplier's investment is more valuable within the relationship than outside it. Therefore the supplier underinvests. If we denote the supplier's optimal investment level in this case as $I_{1a}(\theta_i)$, the ex ante expected profit of the OEM is: $E\Pi_{OEM} = E[v(\theta_i, I_{1a}(\theta_i)) - f(\theta_i, I_{1a}(\theta_i))]$.

Case I b) Sequence of contracts, supplier makes tioli-offer in period $t = 2$

In $t = 2$, the supplier offers the OEM his outside option, which we denote by g, according to the same rationale as in the previous case. We make the assumption that the OEM's outside option does not depend upon the effort provided by supplier i, which can easily be justified.[8] Then in period $t = 0$, the supplier's maximization problem becomes $\max_I v(\theta_i, I_i) - g - c(I_i)$, leading to the first order condition $v_2 = c'$. Therefore,

[8] The results from contacting another supplier do not directly depend on the effort the first supplier has provided, for example.

this contract induces first best effort from the supplier chosen in $t = 0$. Analogous to above, we denote this effort level as I_{1b}. The ex ante expected profit of the OEM in this case is simply g.

Case II a) Supplier competition, OEM makes tioli-offer in period $t = 2$

The situation in $t = 2$ does not change: the supplier can at least retrieve his outside option $f(\theta_i, I_i)$ outside the relationship with the OEM, i.e. the OEM cannot employ competition to drive down prices in this setting. What does happen, though, is that any given supplier i is only awarded the contract in $t = 1$ with the probability $p(v(\theta_i, I_i) - f(\theta_i, I_i) \geq \sup_j v(\theta_j, I_j) - f(\theta_j, I_j))$ with $i \neq j$, which we abbreviate by $p_i(\theta_i, n)$. For this subcase, it turns out that p is irrelevant, as each supplier is awarded exactly his outside option $f(\theta_i, I_i)$.[9]

Therefore in period $t = 0$, the supplier maximizes $\max_I f(\theta_i, I_i) - c(I_i)$ as in **I a)**, which gives us the same first order condition $\frac{\partial f(\theta_i, I_i)}{\partial I_i} = c'$. Nevertheless, the problem is different to the prior case. While in **I a)**, the OEM chooses a single supplier at random from $Q(\theta)$, he is able to select the highest-quality supplier out of n when he induces competition. Mathematically, this is an order statistic problem. We know that the maximum order statistic with n draws follows a distribution $Q_1^n = [Q(\theta)]^n$. For non-degenerate Q, this stochastically dominates the original distribution, therefore $\partial E_\theta(n)/\partial n \geq 0$. For any n greater than one, the OEM will therefore expect to derive a higher expected quality of supplier from competition than from contracting with only one supplier directly. By **A1** and **A2** and absent any other costs, case **II a)** therefore payoff-dominates case **I a)** from the OEM's point of view.

Case II b) Supplier competition, supplier makes tioli-offer in period $t = 2$

Here, the situation changes drastically. At $t = 2$ the n suppliers compete à la Bertrand in order to become the one company to be awarded the production contract based on their design. Denoting supplier i's offer to the OEM as b_i, the winning competitor obtains a rent of $v(\theta_i, I_i(\theta_i)) - c(I_i) - b_i$, where the investment costs are sunk at this stage. On the other hand the losing bidders are guaranteed a payoff of $f_j(\theta_j, I_j(\theta_j) - c(I_j)$. In equilibrium, the most efficient supplier will submit an offer to the OEM at which the second most efficient supplier is indifferent between matching the

[9] The winning bidder receives his outside option as the outcome of $t = 2$ bargaining, the losing suppliers receive it because they have to fall back on it.

bid and her outside option. Denoting the most efficient supplier as supplier 1 and the second most efficient as supplier 2, the OEM's payoff at given investment levels therefore is: $v(\theta_2, I_2(\theta_2) - f_2(\theta_2, I_2(\theta_2)$.[10] The most efficient supplier derives a surplus of:

$$v(\theta_1, I_1(\theta_1)) - [v(\theta_2, I_2(\theta_2)) - f_2(\theta_2, I_2(\theta_2))] - c(I_1) \tag{1}$$

Now let us consider the investment decision of individual suppliers in $t = 0$: First let us consider the expected payoffs for the case that she is awarded the production contract later on, conditional on the number of suppliers involved in the competition and the realization of θ_i. Again denoting the most efficient supplier as supplier 1 and the second most efficient supplier as supplier 2, these are :

$$E[(v(\theta_1, I_1(\theta_1)) - v(\theta_2, I_2(\theta_2)) + f_2(\theta_2, I_2(\theta_2))|n, \theta_1 = \theta_i] - c_i(I_i))$$

For notational simplicity, we abbreviate this to $E(S_i|n, \theta_i) - c_i(I_i)$. Note that this expression decreases in n and increases in θ_i for given investment levels. Further, supplier i anticipates that she will be awarded the contract only if she is the most efficient, i.e. with probability $p[v(\theta_i, I_i) - f(\theta_i, I_i) \geq \sup_j v(\theta_j, I_j) - f(\theta_j, I_j)]$ with $i \neq j$. Applying **A3**, this can be reduced to the simpler expression $p[v(\theta_i, I_i) \geq \sup_j v(\theta_j, I_j)]$.

Now, spelling out the maximization problem of supplier i in $t = 0$, we get:

$$\max_I p(\theta_i, n)E(S_i|n, \theta_1 = \theta_i) + [1 - p(\theta_i, n)]f_i(\theta_i, I_i) - c(I_i) \tag{2}$$

This leads to the first order condition with respect to optimal investment:

$$\frac{\partial p(\theta_i, I_i)}{\partial I_i}(E(S_i|n, \theta_i) - f_i(\theta_i, I_i)) + p(\theta_i, I_i)\frac{\partial (v(\theta_i, I_i) - f_i(\theta_i, I_i))}{\partial I_i} + \frac{\partial f_i(\theta_i, I_i)}{I_i} = c' (3)$$

Therefore the investment incentives are strictly larger than in the case in which the OEM makes the take it or leave it offer - two effects are responsible for this: While the supplier will not be awarded the contract with certainty in the second period (which reduces investment incentives vis-à-vis case **I b)**), but he can increase the probability by exerting more effort. In addition, the supplier increases the value of the prize given that it is awarded to him by **A1**. As discussed above, the investment enhancing effects are weaker both for larger numbers of competitors and for lower realizations of intrinsic quality θ_i.

[10] The same bids/payoffs would result from a second-price auction instead of Bertrand competition.

Again denoting a suppliers' investment choice in this subcase analogously to above as I_{2b} and the most and second most efficient suppliers as supplier 1 and supplier 2, respectively, the expected profit of the OEM in this case is: $E[v(\theta_2, I_{2b}(\theta_2) - f_2(\theta_2, I_{2b}(\theta_2))]$.

To enhance intuition, consider the following simplified example: Let supplier quality be uniformly distributed so that $Q(\theta) = \theta$. The suppliers' investment cost function is determined by $c(I) = \frac{I^2}{2}$. The surplus derived from cooperation is $v(\theta, I) = \theta I$ and each supplier's outside option is worth $f(\theta, I) = av(\theta, I)$ with $a \in (0, 1)$. Finally, the OEM's outside option remains g. Here we are able to derive closed-form solutions which we summarize in the following table:

	$I(\theta)$	$E(v)$	$E(\Pi_{OEM})$
I a)	$a\theta$	$\frac{a}{3}$	$\frac{a(1-a)}{3}$
I b)	θ	$\frac{1}{3}$	g
II a)	$a\theta$	$\frac{an}{n+2}$	$\frac{a(1-a)n}{n+2}$
II b)	$(1-a)\theta^n + a\theta$	$\frac{(1-a)n}{2n+1} + \frac{an}{n+2}$	$n(n-1)[\frac{(1-a)^2}{2n(2n+1)} + \frac{a(1-a)}{(n+1)(n+2)}]$

Table 1: Investment decisions, expected surplus and expected profits of the OEM in $t = 0$ (for $Q(\theta) = \theta$, $c(I) = \frac{I^2}{2}$, $v(\theta, I) = \theta I$, $f(\theta, I) = av(\theta, I)$).

2.4 Mistrust and Underinvestment

2.4.1 A Simple Notion of Trust - Trust and Underinvestment

Up until this point, trust does not explicitly play a role in this model. We attempt to integrate this concept in the following way. Assume that prior to their investment choice, it is not certain which subcase, a) or b), will be played later on in the game. Instead, with probability λ it is the supplier who makes the take it or leave it offer in period 2, while with probability $1 - \lambda$ it is the OEM who makes the offer. Correspondingly, the supplier is able to generate a rent above his outside option with probability λ.

How does this relate to the reality in the industry? In our in-depth interviews, the clear picture emerged that OEMs are at great liberty in designing and enforcing contractual details in relationships with suppliers, almost irrespective of the size or market power of their counterparts.[11] Ben-Shahar and White (2006) report equivalent or even

[11]See Müller, Stahl, and Wachtler (2008) for details.

more pronounced findings for the North American automobile industry. At first glance therefore it would appear as if only the **a)**-subcases (allotting the entire bargaining power to the OEM) described above are relevant with respect to reality. This confrontational setting, in which the relationship is defined mainly through the pure holdup-problem, is often subsumed under the term of an "American" procurement strategy. Yet the global success of Japanese car-makers beginning in the 80s has prompted much interest in alternative ways of supply-chain management, perhaps most famously incarnated in the MIT's International Motor Vehicle Program. As a result, researchers started to stress the importance of cooperative and mutually beneficial relationships between OEMs and suppliers in the industry in achieving the goals of lean production. In this context, Taylor and Wiggins (1997) show that granting the suppliers positive economic rents can be a substitute for control (i.e. monitoring quality levels and eventual punishment).[12] Traditionally, cooperative relationships are prevalent in the Japanese automotive industry and were common practice in Germany at least up until the mid-90s.

Now, consider the entire game from the previous sub-sections to be only the *stage game* of a (potentially infinitely) repeated Markov-game. λ then is a state variable that depends on the (unobserved) previous history of the game. At the point in time in which the stage game that we observe is played, λ is given and resembles the subjective probability which which subcase b) will be played in this period, i.e. the probability with which OEM respects the supplier's property rights. This is precisely our definition of trust in the following: Higher values of λ denote a higher probability with which the OEM will grant the supplier the extraction of a share of the rent generated within the relationship - in other words, the higher λ, the more the supplier *trusts* in the OEM's willingness not to exploit his superior market power.

We refrain from spelling out the repeated game for the following reasons: First, the data on which we base our accompanying empirical analysis are cross-sectional without a panel-dimension. Therefore, what we observe can be considered exactly one period of the stage game, in which the current relationship-specific levels of trust are exogenously given, and this allows us to apply the model more directly. Second, in this setup of the model, what matters is the supplier's level of trust toward the OEM. We believe that the main driving force in these relationships is the hold-up problem and therefore our

[12]See also Aghion, Dewatripont, and Rey (2002) for qualitatively similar results in a more general setting not limited to supplier-manufacturer relationships.

objective is to see whether and how this can be mitigated by the belief of suppliers that abuse is less (or more) likely. Finally, looking at this reduced form allows us to remain agnostic about the reasons for the OEM wanting to grant the supplier this rent.[13] As in Taylor and Wiggins (1997), there could be a tradeoff between rent extraction and control costs, or relatedly, it may be worth while to make the supplier fear the consequences of the relationship being terminated as in Akerlof and Yellen (1990). As an aside, if the OEM were able to commit to a level of λ in the stage game, it is easy to show that for a wide range of parameters it would want to choose $\lambda \in (0, 1)$.

The model allows us to make state our central prediction very straightforward: *Higher levels of trust should be associated with higher relationship specific investments by suppliers.* This holds for any given procurement strategy chosen by the OEM. Across strategies, preselection of an individual supplier should induce (weakly) higher levels of investment. Even this reduced form model conveys some of the complexity of the procurement decision, which also depends on the level of quality uncertainty regarding the product. Clearly, all else given, higher levels of quality uncertainty will induce procurers to induce competition between more suppliers.

3 Empirical Analysis

3.1 Source of Data

Our data results from an online questionnaire study that was carried out for the German automotive industry association[14] (VDA) from Fall 2007 until Spring 2008. The questionnaire was designed on the basis of the results of a case study performed in Spring 2007, in the course of which interviews with high ranking executives in the Automobile industry were conducted.[15] We obtained a unique view of the relationships between original equipment manufacturers and their tier 1-suppliers, with a twofold approach: First, each of 13 participating suppliers was asked to evaluate their relationship with each of up to 11 OEMs active in the German market for different representative products in their portfolio in clinical detail - more than 300 questions were asked covering

[13]For the game to be on the equilibrium path, the subjective and the objective probability of subcase b) being played would have to be the same.

[14]Verband Deutscher Automobilunternehmen e.V.

[15]For the qualitative results of this case study, see Müller, Stahl, and Wachtler (2008).

all central functions within the firms. In addition, the participating OEMs were asked to evaluate their sourcing relationships in general - i.e. not specifically for individual suppliers - for each of the four different product classes according to the established industry classification:

- **Commodities:** physically small and technologically unsophisticated (e.g. shock absorbers)
- **High-tech Components:** physically small but technologically sophisticated (e.g. electronic brake component), in the following referred to simply as component.
- **Modules:** physically large but technologically unsophisticated (e.g front end)
- **Systems:** physically large and technologically sophisticated (e.g. break system)

As OEMs answered a set of questions almost identical to the supplier questionnaire, we are thereby able to compare their view of their general policies with the suppliers' view. In total, more than 1,500 questionnaires were filled in by competent engineering-, procurement- and sales officers with the following methodology. A participant first would have to indicate his function within the company out of the following[16]:

- Pre-development: "Basic" technological research, not model-specific.
- Vehicle Development: Car-model specific (technology adaptation).
- Series Production
- Quality Control
- Sales
- Logistics
- Aftermarket

[16]For a detailed description of the individual functions and the automobile development and production process, we refer to Müller, Stahl, and Wachtler (2008)

Then she would choose a product for which she had the necessary know-how as well as the customers she worked with, the latter from a list. For each product and customer, she would then answer a set of questions suited to her function within the company.

One observation in our data is composed of the answers of the *entire* supplier questionnaire for a given product and a given customer. This exceeds the extent of any given function-questionnaire listed above - therefore, in order to obtain as complete observations as possible, we merge the answers from a given supplier, product and customer over all functions to cover all aspects of the relationship. What each observation therefore describes, is one view (potentially of many people) of the relationship between the supplier and a given OEM for one product. We merge this with the results from the OEM-questionnaire in order to be able to control for the non supplier-specific behavior of OEMs.

On paper, we have 792 observations, but for two reasons these are not necessarily complete: First, not each function within a company filled out a questionnaire for each product studied. In this case, whole sections of the questionnaire are missing for the observation covering the given product. Second, participants could skip individual questions and made ample use of this option. Therefore the numbers of observations over the individual questions differ substantially, as seen in the descriptive data below.

Finally, we perform consistency checks for the answers to the questionnaire by merging the resulting data-set with balance-sheet data of the participating companies as well as break-down and callback statistics obtained from independent sources.[17]

3.2 Descriptive Statistics

The underlying questionnaire sought to depict complex relationships in hitherto unmatched detail. In the following subsections, therefore we will exert effort - perhaps more than usual - to introduce the variables of the study and shine some light on the basic forces and tensions that are at play between manufacturers and suppliers.

[17] For breakdowns, we used the ADAC failure statistics (ADAC is the German AAA), for callbacks we refer to data provided by www.kfz-auskunft.de

3.2.1 Participating Companies and Characteristics of Parts

On the OEM side, 10 of the largest players in the German market participated actively in the survey, 7 producers of passenger cars and 3 truck makers. On the other hand, 13 suppliers active in the German market provided their input on 11 manufacturers - i.e. the 10 participating plus one further car manufacturer. The supplier sample is very strongly biased towards large participants, with average 2007 revenues of 9.4 billion Euro (std 12.4) and even the smallest participant posting revenues above 700 million Euro. This is emphasized by the self-reported European market shares for the product in our sample: For 161 observations this was provided on a five point scale with an average of 3.76 (std .90), which translates into a share of more than 25%. Not surprisingly, the correlation of market share with intensity of supplier competition - also on a 5-point scale - is negative with a value of -0.20 (significant at 5%-level). Further, we observe a negative correlation of supplier size (measured by the 2007-revenues in billion Euros) and the intensity of supplier competition (-.144, p-Value: .072) and a positive correlation of supplier size and market share in the observed part (.124, p-Value: .083).

This could raise the worry that the larger suppliers may be able to exert monopoly power over OEMs for some of the parts we study - to counter this, we made sure that there are at least two suppliers active in Germany for each part in our sample. Nevertheless, we will have to try to control for relative market power in our regressions, as it may clearly affect bargaining strength and the OEM's outside option.

Apart from their type, products are further specified by the R&D-share of total costs as well as the assessment by the supplier how important the degree of innovation is for the particular part. Both were measured on a 5-point scale - the importance ranging from 1 - very little - to 5 - very high, while the cost-shares were provided in 2% increments, therefore ranging from $< 2\%$ to $> 8\%$. As one would expect, the answers to the questions are strongly correlated (0.27, significant at 0.05%-level). More interestingly, though, they allow us to revisit the merits of the underlying type-classification. The following **Table 2** displays the descriptive statistics for these questions by underlying product type:

Performing pairwise t-tests shows that the means for both variables are significantly lower for commodities and modules than for systems and components, while among these two groups the hypothesis of equal means cannot be rejected, which is exactly in line with the industry specification discussed above. This allows us to introduce an additional dummy measure of the innovativeness of a part (dummy_soph) which takes

Variable	Mean (Std. Dev.)	Min	Max	Obs
Systems				
Cost Share R&D	4.19 (1.43)	1	5	37
Importance R&D	4.16 (.74)	1	5	50
Modules				
Cost Share R&D	2.06 (1.76)	1	5	18
Importance R&D	2.89 (.76)	1	4	18
Components				
Cost Share R&D	3.48 (1.40)	1	5	21
Importance R&D	3.42 (.87)	2	5	45
Commodities				
Cost Share R&D	2.35 (1.35)	1	5	91
Importance R&D	2.91 (.69)	2	4	93

Table 2: Importance of Innovation and Cost share R&D by product type.

the value 1 if the type is a system or component. Further, to account for potential price differences due to the sheer size of a part, we introduce dummy_big which takes the value 1 for systems and modules.

3.2.2 Characteristics of the Relationship

In this section, we pursue two different goals. While introducing the variables describing the relationships we also attempt to shed additional light on the differences pertaining to product-type. There is a further dimension, in which we can exploit existing variation: As noted above, we gather information on the relationship between OEMs and suppliers over the entire car-model life-cycle. In the following, the distinction between three of these phases is especially important: pre-development, development and series production. The last of these phases, series production, is the least complicated case - suppliers work with existing blueprints and completely designed (or existing) tools to produce given quantities of the part in question. The product and services can clearly be specified through contracts without much room for misunderstanding, for example specifying acceptable failure rates and delivery conditions in detail. The (model-specific) development phase is in many ways less clear cut. While the general requirements that a part has to meet are defined by its function within the automobile (a brake has a relatively specific function and place, given the projected weight and top-speed of the model in planning), a plethora of other parts with which it has interfaces are being designed in parallel. Blue-prints for the part do not yet exist at the beginning of the design phase. Clearly, the objectives cannot be drawn up precisely ex ante in contracts, but are subject to a continuous cooperative process. Finally, these uncertainties become overwhelming when considering the (not model-specific) pre-development phase: Here for example, the supplier is researching brake-technologies without knowing how fast or heavy the model in which it will be used is going to be. In general, more fundamental research is involved here - and, as should be clear from the nature of the endeavor, it is even harder to write specific and precise enforceable contracts regarding the outcomes. As our respondent were involved in the different stages of the product life-cycle, in a way like Brown, Falk, and Fehr (2004) this allows us to exogenously change the level of external enforceability while keeping product and relationship characteristics constant for a number of questions.[18]

As a case in point, we requested suppliers to evaluate the OEM's supplier choice criteria on a six-point scale from 1-no relevance to 6-very important, for each of the phases in the product life-cycle. From the discussion in the literature we would expect "relational" choice criteria to grow relatively less important as opposed to "hard" criteria - such as price - as one progresses from pre-development onward. Our empirical results strongly support this hypothesis. The importance of price strictly increases from an average of 5.10, to 5.37 to 5.70 (t-tests for difference of mean are each significant at the 0.1% level). On the other hand, the importance of trust is respectively 4.89, 4.90 and 4.73 for pre-development, development and series production. Therefore trust is only significantly less important when choosing a series supplier ($p<0.1\%$), while there is no difference between pre-development and development. But with this kind of question, it is easier to interpret relative magnitude of answers: When we look at the differences in differences between the importance of the choice criteria, there is a monotone relationship, with price becoming relatively more important for each step ($p<5\%$ for pre-development to development and $p<0.1\%$ from development to series production).

[18]See **Tables 6-8** in the Appendix for the detailed descriptive statistics on the variables discussed in this subsection as well as some additional control variables regarding timing and compensation within the relationships.

Next, we suggest two proxies for the value of the OEM's outside option (denoted g in the theoretical framework). The first is the share in the volume of the part provided by the supplier to the OEM (measured on a 5-point scale where each point resembles a 20% difference, with 1-<20 and 5->80%). Presumably, it is more difficult to shift a larger share of production away from one supplier to another than a smaller one, therefore g should be negatively related to this measure. Looking at how this measure behaves for the different product types shows that the share provided has statistically non-distinguishable means for modules, components and commodities (the sub-sample means are, respectively, 3.08, 3.26 and 3.23, i.e. at the upper end of the range 40-60%), while for the systems, this value is significantly higher at 4.07 (or at the upper end of the range 60-80%). The reliance on an individual supplier therefore is significantly stronger in the case of systems than for the other types of part.

As the second potential proxy, the respondents were asked to assess how often the OEM chooses to produce a given part himself on a 6-point scale from 1-never to 6-very frequently, with 4-about 50% of cases as a further anchor. This also allows us to create a dummy variable which takes the value 1 whenever the answer is different from *never*. The ability to produce a part himself is perhaps the most intuitive outside option - and it is one of which OEMs are making ample use, as the recent wave of "in-sourcing" demonstrates. In day-to-day business, there can be different reasons for this, most commonly capacity utilization smoothing[19] or worries about suppliers' ability to provide a part as agreed. The comparison of sub-sample means shows that systems and components, i.e. the technologically sophisticated parts, are significantly less likely to be also produced by the OEM himself than commodities and modules, with the latter being the most likely to be in-sourced. This may be due to the fact that physically larger parts are more costly to stockpile and utilize more capacity. Clearly, higher levels of this variable should be associated with a higher outside option of manufacturers, i.e. a higher g.

Finally, we asked the respondents to evaluate the level of specificity of the contractual requirements at different development stages, as well as the "degree of freedom" in relationship in order to be able to generate some insights into the interactions between trust and contract specificity.

[19]Labor laws make short-term adjustments to the workforce all but impossible.

3.2.3 Procurement Decisions by the OEM

We have two sets of variables that measure the OEM's procurement decisions at different points in the product life-cycle, one qualitative and one quantitative.[20]

For the qualitative measure, we asked the respondents to evaluate how often different procurement strategies have been employed by the OEM for each of the different stages. This may appear slightly paradox, as for each part a manufacturer should apply one strategy, but parts are procured anew for each new series of a given model, i.e. there is a new procurement process every 1.5 to 2 years and clearly different strategies could be used at different points of time in the past. For pre-development, the options were *preselection of a specific supplier* and *procurement among a limited number of suppliers*, each on a 6-point scale from 1-*never* to 6-very frequently. For development and series production, a further option was added, *open procurement*, which plays no role in pre-development. Even the purely descriptive results offer some interesting insights. For pre-development, OEMs are actually significantly more likely to contract with specific suppliers (mean 4.43) than to go through a limited competitive procurement process (mean 3.95, t-test for difference of means significant at 1% level.). In contrast to this, pre-selection of suppliers is significantly less likely both for development (mean 3.06) and series production (2.98). On the other hand, for development OEMs are significantly more likely to procure among a limited number of suppliers (5.18), therefore there is a clear shift to more market-based interactions from pre-development to development. The same kind of shift takes place again from development to series production, where procurement among a limited number of suppliers grows less important (4.55), but there is a significant increase in the use of open procurement (2.44 instead of 1.97). Clearly, the picture that has begun to emerge above, i.e. a shift to more arms-length interactions as the product reaches the development and series production phase is supported by these data. We believe this to be driven mainly by increasing contractibility, when viewed together with the results of the quantitative measure.

For this, we asked how many suppliers provided the given service or produce the part in parallel, differentiated for additional phases within each of the (by now) familiar stages. The development stage was subdivided into the phases product planning, product specification, concept development and detailed development (starting from the

[20]For the descriptive statistics of the variables in this subsection and further controls, see **Tables 9-11** in the Appendix.

earliest). For series production, we asked for the number of suppliers at series start, after 1-2 years and after more than 2 years. The results from this appear to be somewhat counter-intuitive. For pre-development there are on average more than two (2.16) suppliers competing in parallel. This number stays about constant in the first stages of development, before it significantly *decreases* for the last development phase down to 1.51. It reaches its nadir at the beginning at series production with 1.20, before it increases again to 1.59 two years into production. How does this mesh with our prior results? The previous questions only aimed at the choice procedure, instead of at how many suppliers are selected. For pre-development, due to the lack of specificity concerning the objectives, open procurement is not feasible - precisely for this reason, there is the greatest uncertainty regarding the outcome of the process. The way that OEMs deal with this - also suggested by our model - is to have multiple suppliers work on the designs. As seen above, these are frequently hand-picked. On the basis of the most promising approach the OEM then enters into the development process. There is a strong incentive for suppliers for their preliminary design to be chosen, as the contractual reimbursement for pre-development work is on average below 60% of the actual costs, whether or not the company is awarded a subsequent development contract. An analogous process is repeated again for the development process, which results in a specific blueprint. With this blueprint, the quality uncertainty is practically eliminated, given that suppliers are generally certified through stringent quality assurance processes, therefore this component is eliminated from the decision problem. In production, fewer suppliers with higher volumes promise the highest economies of scales and the steepest learning curves, therefore the number of suppliers drops significantly at production start. Once these effects have been realized, the OEM can start to bring additional suppliers in.

We believe that this background is extremely valuable and should be born in mind for the following analysis of which role trust plays in the interactions set out above.

3.3 Measures of Trust: Who trusts whom - and why?

Trust is a sensitive concept which has proved to some degree elusive to attempts at explanation by economists. While existing studies have employed either experimental/behavioral evidence or subjects' answers to variations on the question "To which degree can other people be trusted?", our data has the huge advantage that it is relationship-specific: We ask representatives of company A about their stance and misgivings toward company B with regard to the interactions concerning a specific product. Clearly, there are drawbacks to this approach as well that need to be addressed. We devote the following three subsections to determine how robust the individual measures are and whether and how they can be applied. First we introduce the questions that we believe to be related to the concept "trust". Then we use a method well-established in sociology, exploratory factor analysis, to try to shed additional light on the dimensionality of the construct we are observing - i.e., is there only one kind of "trust", or do the questions we observe really depict a construct composed of various different "factors". Finally, we try to pry the black box from **Section 2.4.1** open (if only a slit), by taking a glance at which past outcomes and behavior affect the suppliers' evaluation of trust in the relationship.

3.3.1 How do we measure trust?

We attempt to capture trust in the various supplier-manufacturer relationships in two, not necessarily mutually exclusive ways. One approach is relatively direct, asking to evaluate mutual trust or inquiring which role trust has played for important decisions. The second approach, which we call indirect, is to look at reported behavior for which trust can be considered a prerequisite.

An important context for trust in these relationships is the area of intellectual property. Especially basic, non model-specific research resembles an important share of suppliers' capital and embodies their ability to differentiate themselves - this ability all but disappears, for example, if an OEM were to take a supplier's blueprints for a part and make them accessible to competitors. Much of this know-how is involved in the earliest stages, the pre-development of products, where suppliers showcase their advanced know-how. In our interviews in the preparation of the study, there was a mention of the practice to deny the most advanced technology to OEMs who were expected not to treat it with the necessary care, i.e. who were not trusted.

Therefore as a first **direct measure** of trust, we inquired after the *importance of the trust relationship with the OEM in a firm's decision to initiate a pre-development project* on a six-point scale ranging from 1-"no relevance" to 6-"very high" (from now on **Trust1**). To be able to relate this to other criteria, we asked the same questions for the importance of the factors *sales potential*, *product positioning* and *long-term cooperation*, so that we can use both the absolute value of the answer as well as the relative rank as measures of trust.

As the second direct measure, we asked the question: "*How do you evaluate mutual trust between OEM and supplier with respect to honoring each other's IPR*?" on a five-point scale ranging from 1-"very little" to 5-"very high" (from now on **Trust 2**). While the first question only involves the level of trust of the supplier towards the OEM, the second question is phrased to cover bi-directional trust. Clearly, a disadvantage to this second question is that the supplier must also give an estimate of the other party's assessment.

We already encountered the third direct measure of trust above. For each phase of the product life cycle, the suppliers were asked for their view of the OEM's choice criteria for choosing his supplier (pre-development: **Trust 3**, development: **Trust 4**, series production: **Trust 5**). Again, we have both the absolute value of the importance of trust as well as the relative rank compared to cost, personal contact, duration of cooperation and certification. This is the *supplier's* assessment of the *OEM's* preferences, only, so we clearly need to evaluate the reliability of this measure. Second, analogous to Sapienza, Toldra, and Zingales (2007), we will have to check whether respondents perhaps related their own level of trust in the OEM in these questions, instead.

Our potential **indirect measures** of trust are associated with behavior that is related to IPR protection and to the secrecy of the cost-structure of the supplier.[21] Suppliers state both *how often they provide original research data to the OEM* on a 5-point scale (1-very rarely to 5-very frequently) as well in a separate question how often the OEM provides access to his original research data on the same scale. Clearly, both the levels and the difference between the two values may be of interest. Further we inquire on the same scale *how often the supplier's costs are made transparent to the OEM.* An interesting issue with these measures which we will have to attempt to disentangle is whether suppliers are forced into revealing these data due to the OEM's superior market power or whether this is truly a result of trust. In order to determine this, the relation between the frequencies with with a supplier and the OEM reveal original research data will be of interest and we introduce the difference between the two as an additional

[21] The suppliers' costs are an extremely contentious issue in negotiations. Cost-cutting manufacturers (have to) accept that a supplier producing below cost will have to go out of business sooner rather than later. Therefore they traditionally try to negotiate prices that are as close to the costs as possible and begrudge the suppliers any positive margin that they obtain. For an excellent and comprehensive discussion, see the classical Womack, Jones, and Roos (1991).

variable.

As a first step towards better understanding these measures, **Table 11** in the Appendix displays pairwise correlations between each of them. As one would have expected, there is a significant positive correlation between all of the direct measures of trust. For the indirect measures, the picture is more interesting: The frequency with which the supplier makes his costs transparent is *negatively* correlated to two of the direct measures - the importance of trust (from the OEM's view) in choosing his development and series supplier. These measures reflect the attitude of OEMs in the selection and negotiation process of development and series suppliers - it appears plausible that it is the insistence of the OEM, therefore, and not necessarily trust that causes suppliers to bare their costs more frequently, which makes this measure non-satisfactory.

The supplier's provision of original know-how, on the other hand, is not correlated with any of the direct trust measures, while there is a relatively strong significant positive correlation (.443) with the provision of know-how by the OEM. The latter is also positively correlated with the mutual trust regarding the treatment of IPR. What would we expect a "trusting" as opposed to a "forced" relationship to look like? If the OEM forces the supplier to reveal intellectual property secrets, this should negatively affect the level of mutual trust with regard to IPR. Further, we would expect that - in these kinds of relationships - the OEM provides relatively little intellectual property into the relationship himself. Finally, the relative market and bargaining power may play a role in this kind of relationship. To determine, whether this effect truly exists in the data, we regress the difference of IP-secrets provided onto the level of mutual trust with regard to IPR, a dummy whether the product is technologically sophisticated and the supplier revenues as a proxy for relative market power. The results of the OLS-regression are provided in **Table 3** below.[22]

The regression results show a significant negative association of the difference in IP-provision and mutual trust as well as supplier revenue, which, as we showed above, can be used as a proxy for relative market power.[23] Therefore, the lower the relative market power of a supplier, the more likely it is that he provides more original research than

[22]We also performed ordered logit regressions, which are more suited to the structure of the data. The results are qualitatively identical (signs and p-values), we report the OLS regression for the easier interpretability of the coefficients.

[23]The corresponding regression with mutual trust as a dependent and the difference as an independent variable shows a significant negative effect of the difference on trust.

Variable	Coefficient	(Std. Err.)
Mutual Trust IPR	**-0.233****	(0.113)
dummy_soph	0.249	(0.201)
Supplier Revenue	**-0.015****	(0.007)
const.	2.009	(0.413)

Table 3: (OLS) Dependent Variable: Difference in frequency of revealing original research data. 129 obs.

his opposite, which we take as an indication that in these asymmetric setting, enforced revelation (which is negatively associated with trust) does take place. In the simple pairwise correlations the overall effect of supplier provision of IP on our measures of trust is neutral (not significantly different from zero). Therefore there must be information in this measure that countervails the effect of the on average increasing difference in provision of IP. Intuitively, one could imagine there to be three coexisting IP-regimes: One symmetric one characterized by distrust - here, both parties provide little or no research findings to each-other. One asymmetric one characterized by force, the existence of which is suggested by the regressions above. And finally, one symmetric one characterized by trust - here, both parties provide research to each other relatively often and in similar amounts. We try to use the following measure to be able to account for the differences in the three regimes: First we create a dummy that takes the value 1 if the difference between the provided IP is not too large, i.e. no larger than 1.[24] Next, we interact this dummy with the frequency of IP-provision by the supplier.[25] The resulting measure has a significant, positive correlation with the reported mutual trust with regard to IPR (.163, p-value .05).

As a result of these considerations, we are left with the 5 “direct” trust measures. Our knowledge of the relationship between the observed measures up until this point is based on pairwise correlations alone. Factor analysis is a method designed to make better use of these “within” correlations between a set of variables in order to extend what can

[24]Taking this as a not too large difference is somewhat arbitrary. There are two reasons why we find it sensible. People tend to overestimate their own contribution compared to others. Further, the value of 1 leads to the highest correlation of the final measure with our direct trust measures.

[25]This interaction term has the lowest value for the “force” regime (0), low values for symmetric mistrust regimes and the highest values for symmetric trust regimes.

variable	**Factor loading**	**Uniqueness**
(1) Trust1	.594	.648
(2) Trust2	.473	.776
(3) Trust3	.679	**.539**
(4) Trust4	.844	**.288**
(5) Trust5	.771	**.406**

Table 4: Factor loadings and uniqueness reported, principal-factor method, 59 observations.

be learned from them. Using a latent variable approach, it maximizes and records the share of variation in the observed variables that can be explained by one unobserved factor (or more), while reproducing the correlations between variables.[26] The method has been criticized in the past for producing results that are not unique, but we find it perfectly suited to produce a kind of "upper bound" in our exploratory setting, i.e. to explain how much of the variation in our measures can at most be explained through the unobserved underlying factor, which we assume to be (at least associated with) trust. One remaining difficulty that we face is that we only have 59 observations in which all 5 variables are included, but even this low number of observations can be sufficient in a 1-factor, 5-variable model as MacCallum, Widaman, Zhang, and Hong (1999) argue, and we perform a number of tests for robustness.

The following **Table 4** displays the factor loadings and uniqueness of the individual variables using the principal-factor method and limiting the admissible number of factors to 1. The resulting pattern is robust to using the maximum-likelihood estimation approach, to allowing a second and third underlying factor and to recursively eliminating individual factors (thereby obtaining significantly more observations). In all specifications, the uniqueness for the variables that measure the importance of trust in procurement negotiations at different stages (3-5) is close to or below the level of .5, which is seen as the relevant threshold in the literature. Among these, the explanatory power regarding pre-development negotiation (3) seems to be smallest. The general rules of thumb would suggest to remove all variables except for (3-5) from the model.

For us, this entails the following result: It appears that the 5 measures do not capture the exact same thing, i.e. "trust", or equivalently, it seems that the common perception

[26] For an introduction to Factor Analysis, we refer to Harman (1976).

of there being one homogenous kind of trust is inadequate in our context. In the following section we will perform a closer analysis of the potential determinants of trust to achieve an understanding of causal relationships, and therefore the individual meanings of our measures.

3.3.2 Determinants of suppliers' trust - IPR-Holdup, Pay and Fairness

Both our model and our industry survey suggest that the inherent hold-up problem is at the center of trust formation: suppliers "sink" effort into research and design for parts which result in blue-prints. After obtaining these blueprints, the superior bargaining position of the OEM enables him to extract additional rents. Therefore our favored interpretation of trust frames it as the belief of the supplier regarding the probability that the OEM will refrain from such undesired behavior.

To test this, we turned to the suppliers evaluation of such behavior by the OEM in our questionnaire, specifically the frequency of conflicts regarding the treatment of patents and trade-secrets as well as the frequency with which the OEM passes on technological secrets of the supplier to third parties without permission.

Clearly, there are more direct ways to extract rents from a position of power, especially by exerting pressure in price negotiations. Therefore for pre-development we looked at the degree to which the OEM shares in the (considerable) risk of higher than expected costs. For development, we we can use the evaluation of the adequacy of license fees in the case that the OEM makes use of protected know-how of the supplier. And for series production, both an evaluation of the frequency with with the OEM demands lump-sum price reductions in renegotiations as well as the extent to which he attempts to extract cost information by employing sub-supplier management were available to us.

We performed OLS-regressions with the individual trust-measures as the dependent and the measures introduced above as explanatory variables, while controlling for the size and technological sophistication of the part. **Table 5** below presents the coefficients and p-values, neglecting the effects of the product-type dummies.

The pattern that emerges lends itself to interpretation: The first trust-measure (*importance of trust for the supplier to initiate pre-development cooperation with OEM*) is not significantly influenced by any of the answers to the questions aiming at compensation and pay. Instead, there is a very strong (-.637) correlation with the reported frequency of IPR conflicts during pre-development, i.e. the more frequent IPR conflicts,

	Trust 1	**Trust 2**	**Trust 3**	**Trust 4**	**Trust 5**
Pre-Development					
Frequency IPR conflicts	-.637 (.05)	-.323 (.01)	-.632 (.00)	-.149 (.277)	-.416 (.02)
How often does OEM leak supplier's IPR	-.147 (.05)	-.521 (.00)	-.291 (.00)	-.153 (.00)	-.225 (.00)
OEM shares risk of higher development costs	.180 (.06)	-.156 (.31)	.040 (.82)	.242 (.00)	.301 (.00)
Development					
Frequency IPR conflicts	-.302 (.08)	-.463 (.00)	-.450 (.00)	-.118 (.11)	-.089 (.39)
How often does OEM leak supplier's IPR	-.170 (.17)	-.392 (.00)	-.333 (.00)	-.134 (.01)	-.116 (.09)
Adequacy of license fees	-.035 (.74)	.100 (.32)	.398 (.00)	.134 (.04)	.256 (.00)
Series Production					
Frequency price re-negotiation (lump sum)	.007 (.91)	-.124 (.13)	-.079 (.45)	-.180 (.00)	-.265 (.00)
Efforts of OEM to extract cost information	-.026 (.65)	-.042 (.41)	-.038 (.54)	-.151 (.00)	-.166 (.00)

Table 5: Determinants of Trust measures. Coefficients of OLS regressions controlling for product type and (p-values) reported.

the lower this measure of trust. A much weaker, but still significant effect (-.147) results from the OEM leaking sensitive IP-related data more often, also in the expected direction. IPR-conflicts during the development phase have a relatively strong negative effect as well (-.302), the p-value of .08 is in part explained by the smaller number of common observations.

The second trust-measure (*mutual trust with respect to IPR*) follows the same general pattern, though with different individual weightings. Again, the compensation measures show no significant influence on the trust-measure. But here, the leaking of sensitive information shows a far stronger effect (-.521 in pre-development, -.392 in development) than in the former case. Further, in this measure the importance of IPR-conflicts during the development phase (-.463) is higher than during the pre-development phase (-.323), which probably reflects the fact that a higher share respondents to this question were involved in later development stages.

The picture changes for the remaining trust measures three through five (*Importance of trust for the OEM's supplier choice* for pre-development, development and series production respectively). For measures four and five, the importance of IPR-related behavior decreases markedly, while the effects of adequate compensation and price-cutting become significant with the expected signs across the board. Interestingly, the third trust measure, related to pre-development presents itself as a hybrid case, in which the IPR-related factors are still predominant, but nevertheless also the adequacy of license fees plays an important role (.398), while the other compensation related measures do not. The results further provide a judgment on the as of yet unanswered issue of *whose* trust these questions truly measure: As perceived misbehavior by the OEM affects them in a significantly negative manner, we feel comfortable using them as measures for the supplier's trust in the OEM.

To crudely summarize these findings: Trust 1 and Trust 2 are negatively associated with attempts at rent extraction by the OEM in the area of IPR with slightly different focuses, while they are not affected by direct attempts at price-reductons. This balance shifts toward the latter for Trust 3 and even more so for the measures Trust 4 and Trust 5. After going to great lengths to establish these measures, we now try to show that the underlying construct significantly affects relevant economic behavior and outcomes.

3.4 Trust and Sourcing Decisions

work in progress

3.5 Mistrust and Underinvestment

The main hypothesis derived from our model states that higher levels of trust should lead to more relationship specific investment by suppliers.[27] Measuring investment of suppliers poses a challenge. As we do not observe a direct measure, we propose two proxies related to the quality of parts instead. One standard interpretation of quality related effort in the literature is that it affects failure rates of parts (see, for example Taylor and Wiggins (1997)). Along these lines, we asked respondents two questions: *With*

[27]Here, again, one could argue along the lines of reverse-causality: Less investment may lead to more conflicts between the parties, which lets trust deteriorate. While acknowledging this, we find the opposite argument far more convincing.

respect to the part considered, how often do quality problems occur? and ... *how often do recall actions occur in during series production?* Both questions are measured on a 5-point scale with 1 resembling the lowest and 5 the highest frequency. The correlation between them is (only) 0.41, which can be explained by the fact that not every quality problem leads to a recall and the latter are extremely infrequent. As a consequence, 89% of respondents reported a 1-"very infrequently" for the recall question, which poses serious empirical limitations.[28] Specifically, in 50% of the cases in which the lowest possible value for recalls is reported, there is some higher level of quality problems. On the other hand, when quality problems become more frequent/severe (levels of 3 or higher), which in itself is rather rare (17 cases), in 54% of cases respondents report levels of recall frequency above 1.

In general, difficulties arise when trying to assess underinvestment-related quality issues empirically, as a) the observed failure rates of cars cannot necessarily be linked to individual parts, b) the diligence of the manufacturer in assembly also affects quality and c) if quality problems are diagnosed before the parts are installed, this is generally not observable. The huge advantage of our questionnaire is that the responses are part-specific which address issue a). The phrasing of the question address issue c). By including customer- or OEM-effects in the regressions, we hope to alleviate issue b). A potential drawback is the fact that the frequencies are self-reported, so that respondents may be tempted to under-report problems. To counter this, complete anonymity was guaranteed at the outset of the study.

For our empirical strategy, we choose the following approach with κ denoting a constant, y denoting the frequency of problems arising, i denoting the part in question and j denoting the customer:

$$y_{ij} = \kappa + \alpha_j + \beta * trust_{ij} + \gamma * dummy\_soph_i + \delta * dummy\_big_i + \epsilon_{ij} \tag{4}$$

This **Model 1** spells out the set of OLS-regressions including customer fixed-effects (α).[29] To address the issue of subjective differences in the understanding of the questions at hand, we also specified dummies which take the value 1 whenever the answer to the

[28]The model quality, as represented by the F-statistic, in general is very low as meaningful variation is absent.

[29]We also perform (more suitable to the data at hand) tobit and ordered-logit regressions, which delivered qualitatively identical results. We do not report the results in this paper, but they can be provided by the authors upon request.

question is the lowest possible frequency (i.e. 1) and take the value 0 whenever the reported frequency is larger than this. This allows us to estimate a probit-model, in which y is simply replaced by the probability that no problems occur/problems occur as rarely as possible (**Model 2**). This specification has the further advantage that the results can be more readily interpreted. We would expect negative coefficients for β in Model 1 and positive coefficients for β in Model 2 from our hypothesis.[30]

We estimate both models with and without customer fixed-effects. We include these to capture, for example, potential complementary effort exerted by the customers (OEMs), which also may influence the probability of quality issues arising. As this effort may affect supplier incentives to provide better quality, it is not clear how these effects are directed. As a consequence of the very limited variation in the frequency of recalls, we only present the set of OLS regressions for this question to show that the trust measures contribute explanatory power in the cases that recalls are reported. The results of the three sets of regressions can be found in **Tables 12-14** in the Appendix.

First note that the coefficients in all estimations have the expected signs, though their levels of significance vary. The latter can, to a large degree, be explained by the fact that different numbers of observations are available for the individual regressions. In those including Trust 4, which include the highest number of observations (122), β is significantly different from zero at the 5% level for all specifications. As one would expect, both technological sophistication and size (or interfaces within) raise the probability of quality issues significantly across the board. The size of the coefficients is noteworthy - more complex parts that are both technologically sophisticated and large are more than 50% more likely to have quality issues. The other surprising result is the extent to which our measure Trust 4 influences the quality level as reported by suppliers. An increase in the measure by 1 (i.e. 1.1 standard deviations) *decreases* the probability of quality issues arising by 12.9% (excluding costomer fixed effects) or even 16.7% (including customer fixed effects). We take this as first substantial evidence in favor of our central hypothesis.

4 Conclusion and Outlook

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[30] As Model 1 makes use of more variation within the outcome variable, it uses the existing information more efficiently.

5 Appendix: Descriptive Statistics and Regression results

Variable	Mean (Std. Dev.)	Min	Max	Obs
When is supplier asked to participate?	2.77 (1.37)	1	6	144
How often is progress coordinated?	2.98 (.57)	1	5	151
Share of efforts absorbed by Supplier	3.50 (1.33)	1	5	142
Cost reimbursement if subsequent contract	2.31 (1.52)	1	5	246
Cost reimbursement if no subsequent contract	2.39 (1.59)	1	5	232
Specificity Development Objectives wrt...				
... content	2.33 (.97)	1	5	350
... time-frame	1.85 (.96)	1	5	350
... financial engagement	2.22 (1.14)	1	5	343
OEM'S Supplier Choice criteria:				
... importance of supplier price	5.10 (1.16)	1	6	158
... importance of duration cooperation	4.70 (.99)	1	6	160
... importance of trust	4.89 (.98)	1	6	159

Table 6: Relationship Characteristics: **Pre-Development** (Suppliers' view)

Variable	Mean (Std. Dev.)	Min	Max	Obs
How specific and detailed are specifications?	2.39 (1.02)	1	5	231
Supplier's degree of freedom	2.91 (.86)	1	5	231
Desired degree of freedom	3.62 (.77)	1	5	229
OEM's contribution to development	2.37 (1.10)	1	5	200
Frequency of IPR conflicts	2.24 (.87)	1	5	194
OEM'S Supplier Choice criteria:				
... importance of supplier price	5.37 (.72)	2.5	6	387
... importance of duration cooperation	4.52 (1.00)	1	6	387
... importance of personal contact	4.52 (.98)	1	6	387
... importance of certification	4.39 (1.14)	1	6	377
... importance of trust	4.90 (.93)	1	6	384

Table 7: Relationship Characteristics: **Development** (Suppliers' view)

Variable	Mean (Std. Dev.)	Min	Max	Obs
How often does OEM produce part himself:	1.69 (1.31)	1	6	210
OEM'S Supplier Choice criteria:				
... importance of supplier price	5.70 (.52)	3	6	253
... importance of duration cooperation	4.38 (1.07)	1	6	253
... importance of personal contact	4.44 (1.10)	1	6	253
... importance of certification	4.28 (1.19)	1	6	250
... importance of trust	4.73 (.98)	1	6	252

Table 8: Relationship Characteristics: **Series Production** (Suppliers' view)

Variable	Mean (Std. Dev.)	Min	Max	Obs
Number of competing suppliers	2.16 (.84)	1	5	137
Frequency of subsequent development projects	3.23 (1.11)	1	5	322
How often were projects discontinued in last 5 yrs.	2.00 (.88)	1	5	139
How often were the following employed...				
... preselection of a specific supplier	4.43 (1.26)	1	6	351
... procurement among a ltd. number of suppliers	3.95 (1.44)	1	6	338

Table 9: Procurement Decisions: **Pre-Development** (Suppliers' view)

Variable	Mean (Std. Dev.)	Min	Max	Obs
Frequency joint procurement dev. and production	3.76 (1.24)	1	5	363
Number of suppliers employed during...				
... product planning	2.22 (1.13)	1	5	167
... product specification	2.03 (1.02)	1	5	177
... concept development	2.12 (1.07)	1	5	208
... detailed development	1.51 (0.90)	1	5	210
How often were the following employed...				
... preselection of a specific supplier	3.06 (1.52)	1	6	259
... procurement among a ltd. number of suppliers	5.18 (1.10)	1	6	264
... open procurement	1.97 (1.41)	1	6	255

Table 10: Procurement Decisions: **Development** (Suppliers' view)

Variable	Mean (Std. Dev.)	Min	Max	Obs
Number of suppliers employed...				
... at production start	1.20 (.58)	1	5	251
... after 1-2 years	1.47 (.78)	1	5	249
... after more than 2 years	1.59 (.81)	1	5	246
How often were the following employed...				
... preselection of a specific supplier	2.98 (1.63)	1	6	248
... procurement among a ltd. number of suppliers	4.55 (1.52)	1	6	248
... open procurement	2.44 (1.66)	1	6	243

Table 11: Procurement Decisions: **Series Production** (Suppliers' view)

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Trust 1	-.052	-.054								
	(.395)	(.42)								
Trust 2			-.072	-.069						
			(.396)	(.51)						
Trust 3					**-.120***	-.099				
					(.087)	(.192)				
Trust 4							**-.133****	**-.159****		
							(.03)	(.022)		
Trust 5									-.066	-.080
									(.437)	(.440)
d_soph	**.298****	**.327****	.085	.144	.049	.084	**.244****	**.271****	**.354*****	**.401*****
	(.026)	(.020)	(.614)	(.418)	(.766)	(.625)	(.024)	(.015)	(.001)	(.006)
d_big	.189	.223	.204	.135	.251	.277	**.218***	**.215***	.183	.186
	(.171)	(.138)	(.26)	(.364)	(.152)	(.146)	(.058)	(.076)	(.193)	(.23)
OEM-FE	**no**	**yes**	**no**	**yes**	**no**	**yes**	**no**	**yes**	**no**	**yes**
# obs.	95	95	67	67	70	70	122	122	90	90
R^2	.102	.162	.05	.171	.092	.238	.118	.162	.126	.187

Table 12: OLS-regression results (Model 1) for frequency of quality problems, coefficients and (p-values).

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Trust 1	.041	.040								
	(.427)	(.487)								
Trust 2			.085	.101						
			(.212)	(.262)						
Trust 3					.096	.111				
					(.111)	(.128)				
Trust 4							**.129****	**.167****		
							(.026)	(.016)		
Trust 5									.086	.092
									(.249)	(.308)
d_soph	**-.240****	**-.283****	-.028	-.084	-.030	.024	**-.207****	**-.237****	**-.298*****	**-.349*****
	(.028)	(.014)	(.836)	(.574)	(.833)	(.881)	(.029)	(.016)	(.008)	(.003)
d_big	**-.224****	**-.278****	**-.278***	-.242.	**-.344****	**-.478*****	**-.246****	**-.258****.	**-.219***	**-.238***
	(.050)	(.027)	(.051)	(.162)	(.015)	(.007)	(.015)	(.015)	(.064)	(.065)
OEM-FE	**no**	**yes**	**no**	**yes**	**no**	**yes**	**no**	**yes**	**no**	**yes**
# obs.	95	95	67	67	70	70	122	122	90	90
Ps-R^2	.096	.149	.074	.186	.103	.241	.107	.138	.127	.169

Table 13: Probit-regression results (Model 2), probability of not observing quality problems, average marginal effects and (p-values).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trust 1	**-.071****	**-.090****								
	(.033)	(.011)								
Trust 2			-.052	-.087						
			(.290)	(.168)						
Trust 3					**-.081****	**-.090****				
					(.027)	(.028)				
Trust 4							-.049	**-.073****		
							(.142)	(.049)		
Trust 5									-.063	**-.116***
									(.204)	(.055)
d_soph	.041	.047	.067	.078	-.018	-021.	.052	.062	.080	.070
	(.568)	(.523)	(.508)	(.471)	(.84)	(.821)	(.389)	(.317)	(.319)	(.398)
d_big	.109	.089	.014	-.054	.080	.060	.087	.061	.075	.040
	(.148)	(.260)	(.898)	(.659)	(.392)	(.560)	(.168)	(.347)	(.360)	(.65)
OEM-FE	**no**	**yes**	**no**	**yes**	**no**	**yes**	**no**	**yes**	**no**	**yes**
# obs.	92	92	64	64	66	66	115	115	87	87
R^2	.077	.195	.033	.155	.089	.210	.048	.118	.053	.153

Table 14: OLS-regression results (Model 1) for frequency of product-related recalls, coefficients and (p-values).

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