Essays on Microeconomic Foundations of Business Strategy

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TABLE OF CONTENTS

1. INTRODUCTION

Management and Economics are treated as distinct sciences, yet they have at least partially the same object of investigation. Management and Economics have mostly different methods of research, yet the goal—efficiency—is similar. The former is concerned with the efficient planning, organization, leading, and controlling of an organization. The latter is concerned with efficiency in the production, distribution, and consumption of scarce resources. This duality is most pronounced in the confrontation of business strategy and microeconomics. As different as the two fields might seem in the beginning, the subject matter is the same, the economically acting subject, and thus they should be able to nurture each other. In the introduction to *Competitive Strategy*, Porter (1980) argues that the field of business strategy lacked an analytical base and that economics might serve for the development of this basis, while itself being insensitive to the needs of business strategy. The counterpart of each strategic decision is a reaction of the market system. Each change in the market system provokes an adaptation of the strategic decisions. Recently this subject receives more attention in the literature as well as in academic education as for example in the text book *Economics of strategy* by Besanko, Dranove, and Shanley (2000), which acknowledges the valuable insights a microeconomic foundation can create for business strategy formulation.

The following three chapters analyze three different settings with economic agents in their respective markets. They try to foster understanding of the microeconomic interactions in the market as a basis for business strategy development in the sense of Porter. They all conclude with hints on the efficiency of market structures and possible business strategies of the companies when being active in these markets in up- or downstream economic interactions. They are all self-contained research papers, and every chapter is followed by a bibliography and an appendix.

Chapter 2 is a survey on a series of deep case interviews with car part suppliers and car manufacturers on their strategic supply and purchasing behavior and it originates from joint work with Konrad O. Stahl and Frank Wachtler. During the recent 15 years, the Automotive Industry has changed significantly. Besides the developments in the downstream sale of cars, also the upstream market from the very small producer of a small car component up until the OEMs themselves have undergone significant changes. Especially it has been observed that OEMs have reduced the number of upstream suppliers they are directly dealing with, while their vertical depth of manufacture simultaneously decreased. This has given rise to new players in the market, system or module suppliers. The survey contains the answers of 15 suppliers and three car manufacturers on questions concerning the parts supplied, the organization of purchasing, the supply strategies, the information about other players in the market, the contractual arrangements, and the competitive situation. It discusses some fundamental facts of the automotive industry in the light of economic theory, e.g. the issue of contract incompleteness or information asymmetry, and it presents specific observations that we regard as key findings and implications both for the industry practice as well as economic theory. The goal of the survey is to improve the understanding of the different players' actions especially under the recent changes and to analyze as well as evaluate the developments resulting from players' actions. In the end this may add to recommendations for a more efficient industry structure in the future.

Chapter 3 complements chapter 2 with a theoretical model on the supply behavior under the light of incumbency advantages for one supplier and switching cost on the side of the procurer in an infinitely repeated game. It originates from joint work with Frank Rosar. We model a procuring firm's problem of repeated procurement for a similar good. The procurer faces two types of potential suppliers: one incumbent and several entrants. Only the incumbent can make a relationship-specific investment, increasing the benefits of the repeated cooperation for the procurer. The procurer faces the main trade-off between reaping benefit of repeated cooperation with the incumbent, and foregoing that benefit by awarding the contract to a possibly more efficient entrant while exercising higher market pressure. The role of the incumbent is endogenous in the infinitely repeated game. The goal of the paper is to compare two types of mechanisms that are derived from stylized facts of existing procurement processes. Referring to the automotive industry, we identify one mechanism with the procurement behavior found in Keiretsu-like relationships in Asia. Whereas the other resembles the (seemingly) more aggressive procurement behavior in Europe and North America. We show that no procurement mechanism dominates the other. So the answer to the quest for the best mechanism needs to be: both, depending on the ability to realize benefits from cooperation and to extract the proceeds afterwards from the suppliers. This should be reflected in the procurement portfolio of firms, which could exhibit large variations, e.g., between standardized and new products, simple and sophisticated products, supply from countries with high or low cooperation potential. Furthermore, we suggest that in long-term contract models the pressure on the suppliers does not need to be lower, just because one observes obvious market interactions—like procurement auctions—less frequently.

Chapter 4 covers pricing strategies of oligopolistic companies and originates from joint work with Andrey Ivanov. Conventionally, we think of an increase in competition as weakly decreasing prices, increasing the number of consumers served, thus increasing consumer surplus, decreasing firms' profits, etc. Here, we demonstrate that, under some tame circumstances, an increase in competition may lead to a price increase in a horizontally differentiated market. We show this relationship for the petrol market in German cities. The results of this chapter suggest, that for firms in a tight market it might be the profit maximizing strategy to raise prices as a response to an increase in competition. Given that the firms only need to realize the price elasticities of their demand correctly, and without explicit communication or collusion in the market, conventional measures of market concentration in order to prevent monopolistic structures might be misleading.

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2. AUTOMOTIVE UPSTREAM – A CASE STUDY

2.1 Introduction

Game and contract theories with their extensions to the design of allocation mechanisms, and their applications to the theories of the firm and industry are arguably amongst the most interesting and influential microeconomic theories that have emerged during the last thirty-five years. Bringing these theories to statistical data, however, suffers from the problem that many assumptions essential in driving the results are well beyond the detail captured in the data. Hence many theories remain unchecked empirically.

An additional important facet is brought in by the fact that efficient contracts or other mechanisms proposed by theory are often never implemented in practice, because sophisticated mechanisms may be unnecessary, infeasible, or too costly to implement. In view of this, it seems important to see which mechanisms are actually used, to seek the reasons for apparent inefficiencies, and possibly to improve on them. In other words, the development of new theory in this realm should rest on assumptions that are based on empirically founded generic statements, rather than on assumptions that are, while plausible, often rather ad hoc.

With the present research we attempt to fill the gap between theory building and empirical observation and testing, by introducing a case study approach in which the case questions discussed are based on theory, and the context in which they are raised is hopefully specified to an extent that allows the reexamination of extant theory, and new theory building. The case data are generated from in-depth interviews of the management personnel of German automotive producers' procurement divisions, as well as of the personnel of upstream suppliers' R&D, and sales divisions.

The automotive industry exhibits properties that rather ideally serve the purpose. No other mass market consumer product is more complex, and consists of more individual product specific parts, than a modern vehicle. The number of parties engaged in producing and collating these parts is large, and the interfaces between the parts are of a complexity that necessitates particularly detailed coordination. Modern vehicles contain an enormous amount of innovative features in many technological dimensions. Vehicle parts are idiosyncratic to an extent that extremely few parts are used in any two different vehicle models, even if supplied by one automotive manufacturer (henceforth called OEM, Original Equipment Manufacturer). All these properties lead to contractual relationships, in particular between OEMs and their direct suppliers, that span between very personal relational contracts and impersonal arms length relationships.

The automotive industry has changed significantly during the recent 15 years. Two features dominate. Firstly, the typical OEM's product portfolio has broadened significantly, to the extent that product portfolios have become more similar. This, amongst other features, has substantially increased the intensity of competition between similar vehicles.[1]

Secondly, the OEMs have outsourced significantly. Yet at the same time they also have reduced the number of suppliers they are directly dealing with. New supplier types, called system or module suppliers, have emerged. While a system supplier is characterized by integrating several components into a functioning system, module suppliers are merging neighboring components that functionally do not necessarily interact with each other. Examples for a system are the vehicle electronics, or the brake system integrating products from the brake pedal to the brake disks; and for a module the front end, combining the bumper, headlights, radiator and other smaller parts.

Many features of automotive production processes have already been discussed in the literature. In particular, the striking difference between the Japanese and the U.S. way of organizing upstream supply has been discussed in detail. Also the question of in- vs. outsourcing has been subject of research, as discussed, for instance, in the classic example of General Motors and Fisher Body.[2]

Yet a large number of open questions remains related to positive and normative aspects of organizing the upstream sector in the industry as a paradigm example. Some of them are derived from the case study evidence in the sequel of the paper. They largely relate to the mode of upstream innovation, and series supply procurement and compensation schemes.

Our research is geared by two interests. Firstly the methodological one introduced before. We wish to bring data closer to the theory and vice versa, in the hope of mutual cross fertilization. In particular, we attempt to show where theory in its current state helps us interpreting what we observe. By bringing data closer to theory, we also hope to filter out the pertinent models from the overwhelmingly rich set of variants offered to date. Complementarily, we hope to suggest aspects where additional theory is needed to explain the empirical observations.

Secondly, we wish to contribute specifically to an understanding of the players' actions in the automotive industry by analyzing and evaluating the consequences of their actions, towards recommendations for a more efficient upstream interaction, and industrial structure in this important sector.

The sequel of the paper evolves as follows. In section 2.2 we outline our case study interview approach. In section 2.3 we survey key findings from

[1] In the sequel we will only *passim* touch upon this interesting observation. The reasons for this do merit further analysis.

[2] See Klein, Crawford, and Alchian (1978) among others.

in-depth case interviews with senior management sales officials of upstream suppliers, and procurement officials of OEMs in Germany, and structure them by microeconomic principles. In section 2.4 we derive research questions and hypotheses, that upon further analysis are geared to answer these questions. We summarize in the concluding section 2.5.

2.2 Case study interviews: approach

The focus of our case study was on the incentive structures involved in upstream procurement and their change, primarily wrt. research and development, production planning and execution, and also quality management and logistics. All these dimensions can be addressed within formal contracts between the parties, as well as within informal arrangements.

Due to the complexity as well as sensitivity of the issues addressed, we chose an open, personal interview format. Interviews of on average about two hours were conducted at the supplier level with senior management personnel responsible for research and development, production and sales; and at the OEM level with management personnel responsible for parts procurement. The interviews were organized around eight thematic blocks, with a total of some 70 general questions. These covered the product discussed, its buyer and supplier market, the contracting process for research and development, as well as series and spare part production, and finally the resulting after sales market activities.[3] The sequencing of topics pursued in the interviews was flexible. The questions served to control for completeness rather than to prescribe a strict schedule. The Appendix contains questionnaire versions for the upstream suppliers and the OEMs that mirror procurement from the two player categories' point of view. The questions discussing the same subject matter have the same number. The interviews were conducted between November 2005 and May 2006.

Overall 45 upstream suppliers and 7 OEMs were approached towards an interview. The companies were collected from the member list of the Verband Deutscher Automobilunternehmen (VDA). All OEMs producing motorcars were considered. Upstream suppliers were selected to generate a representative sample of the industry, where product complexity, customer specificity and strength of market position are the key characteristics that differentiate suppliers. Interviews were conducted with 17 companies. Each interview of an upstream supplier focused on a representative product range for that

[3] After sales market activities involve selling parts of vehicles that are no longer produced and sold anew, for which the OEM extends an implicit guarantee that these parts are made available for about 15 years after end of production.

company. One of the suppliers was available for interviews in two divisions, that are acting in economically as well as technically different markets.

In all, we consider a total of 15 supplier and 3 OEM interviews in the ensuing analysis. Of the OEMs interviewed, one is a high-volume vehicle producer and one is a pure premium vehicle producer. The third offers a mixed product portfolio. Amongst the 15 suppliers, one was characterized by simple products with a low customer specificity and a weak market position, seven were characterized by complex products with a low customer specificity and a medium market share, six by complex products with a high customer specificity and a medium market share and one by complex products with a high customer specificity and a large market share.[4]

Overall the interviewed companies had sales well in excess of EUR 100 billion, and employed more than 350.000 staff in 2004. The diversity of the interviewed suppliers is also illustrated by their highly varying size, ranging from sales of 200 million up until several billion Euros, and employment figures between 2000 and well over 10.000. Average sales of all interviewed companies were 6.8 billion and the median was at 1.9 billion Euros. The average number of employees was 21.000, and the median number was 9.000.

Before we report on the results of our interview study, we should emphasize that the interview results may be subject to bias. Naturally we observe only the firms surviving in the market. Firms unsuccessful in the past are likely to have exited. Since the typical OEM is too big to fail, this self-selection bias is relatively more pronounced at the upstream supplier level. In addition, of the companies still active in the automotive industry, managers of more successful companies might be inclined to talk more openly about their business, than managers of less successful ones. Our interviewees may also tend to overemphasize current business developments relative to long-term changes. For example, while we observe a long run increase in outsourcing activity, the interview partners emphasized the recent slight backswing. Many answers given in the interviews include very sensitive information. In addition, supplier markets for certain parts are thin, sometimes with only two or three players in Europe or even world wide. Also the number of OEMs worldwide is very limited. We have taken utmost care to anonymize all statements.

[4] The characterization of suppliers was performed outside in via a cluster analysis, based on annual reports and auxiliary information available on their web sites.

2.3 Procurement structures in the automotive industry: evidence

2.3.1 Overview on interaction structures

As emphasized before, there are very few standardized commodities involved in the upstream procurement for automobile parts. Most parts, even O-rings or screws in a vehicle are produced specifically for one vehicle model, in specific size, material, or machining. Thus there are very few products taken off the shelves to be sold to different car producers, or even to one car producer as carry-over parts, towards use in different models.[5]

The various parts are highly complementary in development, production and delivery. The production process is very sensitive to supply delays, as most parts are no longer held in stock. Often the parts are characterized by very complex interfaces to each other, a feature that affects research and development, production, and part functioning, including part failure and its consequences. In consequence the activities of all parts suppliers are strongly complementary to each other when concentrating on one car model.

All of this calls for complex models of vertical restraints, with several competing principals (the OEMs) and multiple competing agents (the first tier upstream suppliers). Theoretical models on vertical restraints are for example covered in the survey by Katz (1989). Note that externalities abound in this structure. The actions of one party affect the profits of many, if not all others, but the party typically takes its decision based only on the effects of its own profits or utility.

The interaction is complicated by the fact that endogenous fixed and endogenous variable costs interact in a very intricate way. R&D efforts constitute a major part of fixed costs. When conceptualizing a model, the OEM typically thinks of so called unique selling properties (USP) in which the model should provide innovative advantage over similar models offered by competing OEMs.[6] Research and development for a particular part could in principle be performed by the OEM, by his supplier, or by a joint effort.

However, the OEM typically directly contacts particularly innovative suppliers, and adopts one of the gadgets developed by them, or initiates tenders between a preselected small group of potential suppliers, towards the development of of a concept for these innovative parts along the desired specifica-

[5] In the automotive industry's jargon, all parts are called *commodities* that are similar in all vehicle models and produced without major R&D effort. This involves a large share of parts but a small share of the total value procured.

[6] These properties sometimes extend into the larger share of the OEM's portfolio of models.

tions. If several suppliers participate, then the concept competition phase for that part ends with each supplier submitting a proposal for the construction of that part, including a price quote for development and production.

Supplier efforts during this phase are most often not directly compensated by the OEM. The supplier undertakes basic R&D efforts (about 10 per cent of his total R&D outlay) at his own expense and risk, often in close contact to universities and other research facilities, and presents the results to one or several OEMs. In the ensuing pre-development phase the supplier engages, sometimes in cooperation with a particular OEM, in the development of a prototype not geared towards a particular vehicle model, with the cost again borne by the supplier or shared with the OEM. In most instances, the development of the model specific part is also conducted by the supplier, but under the OEM's close supervision. Sometimes this supervision is extended into a joint development effort with the OEM.

Variable costs primarily arise per piece supplied. The OEM selects one or possibly several suppliers to develop the part to production maturity. Then often another tender is held, and the winner is awarded the series production contract or portions thereof; for instance, the initial year of series production. In most cases parts are procured from one supplier only at a time. Dual sourcing, with the second firm assigned a smaller share of production volume, is rarely used amongst German OEMs. Finally, second sourcing, with a second source nominated, but no production share availed unless the first source drops out, was not observed at all.

For many reasons including capacity utilization in development and production as well as brand marketing, the typical OEM launches individual vehicle models in different years. The observed pattern exhibits an overlapping generations (OLG) structure. This is reflected in an OLG structure of supply contracts, often with the same supplier. When contracting parts for a new vehicle model, the OEM frequently uses the occasion to renegotiate procurement contracts; in particular prices, for parts built into running models.

Schemes to reimburse the supplier's development efforts towards model specific parts vary between coverage of a fixed share by the OEM, and coverage by a mark up on production costs, rarely with a volume guarantee by the OEM. Almost all production contracts account for learning cost savings varying between 3 and 5 per cent p.a. The aforementioned renegotiations are often geared towards the OEM's increased participation in such cost savings.

In the following subsections we structure upstream-downstream interactions, and our case study evidence. This should help the development of research questions and hypotheses on upstream procurement behavior and its economic effects pursued in the ensuing section 2.4.

2.3.2 Contractual incompleteness

Upstream supply contracts in the industry exhibit a variety that ranges from very specific, to general framework contracts that outline a general understanding between the supplier and the OEM on the procurement of a part during the life cycle of a model. The shell for all contract forms is typically provided by the OEM within *General Terms and Conditions*. A development, or supply contract typically contains the following specifics: Contract duration; dates and terms of supply; parts specifications and changes of those; quantity, logistics (order flow); quality and warranty management; payment terms; cancellation payments, and intellectual property rights on newly developed components.

There are very few, if any, contracts that can be called complete.[7] Incompleteness arises wrt. elements that are technically not verifiable (see below) or are too costly to specify in a contract. They also do not cover all eventualities (possible states of nature). Court cases are rare and thus verifiability is rarely an issue, for an obvious reason: Most interactions are repeated, and thus it is not in the interest of at least one contracting party to draw the opposing party into costly court rulings.[8]

More specifically, our case study interviews suggest incompleteness primarily in the following dimensions.

Attributes of the part are inherently specified incompletely at the moment the development contract is written. Conversely the supplier's development effort intensity is both not specified and not verifiable.

Quantities procured by the OEM are specified typically via the OEMs' target vehicle output quantities over the model's entire life time. Yet the effective quantities demanded are dependent on the final demand for the model. That is realized only in the short-run, and effectuated in the OEM's release orders weeks or days before delivery. The contracts specify the release order procedure. The supplier determines his capacity largely at his own risk. The OEM very rarely grants volume guarantees.

[7] Interview results: Contracts used are widely incomplete and augmented with (partially not verifiable) side agreements (Yes=7, N/A=9, No=2), such that the value of contracts for the relationship is limited.

[8] Results from the interviews for the use of court procedures showed 6 'No', 12 'N/A' and no 'Yes'. Amongst the 6 'No', 2 suppliers explicitly stated they would not engage into court procedures on patent infringements, 2 would not engage in procedures against the OEM, if he disclosed research results to competitor suppliers, 3 stated that they would not engage in procedures against OEM in general (also general disregard of contracts was mentioned).

Reliability is typically exercised within contractual terms, in form of maximal failure rates (parts per million) required by the OEM, and so are payment flows when responsibilities for failed parts are clearly identifiable. Contracts typically remain unclear with respect to failures involving externalities discussed below, in the section on reliability risk.

Prices at which the part is delivered to the OEM are always precisely specified for the initial delivery period, e.g. one year. Framework contracts, however, include further delivery periods up to over the model lifetime. If such a contract is written, then prices for ensuing periods are either pre-specified, with stepwise price reduction schedules to account for learning effects on the supplier side; or prices are renegotiated annually. In either case, price specifications are likely not to be binding. The OEM may enforce renegotiations under breach of contract, which contributes to contractual incompleteness.

Switching suppliers: While the discontinuation of a supply contract appears to be a rare event, the conditions for a discontinuation apparently are almost never completely specified. One of the few provisions from the procurer's point of view is the property right over model specific tools typically also financed by him. While in theory the tool can be transferred between suppliers, the switching cost involved in the transfer is very high, as stated by both OEMs and suppliers.

There are other components of the supplier-buyer-relationship, that seem to be not specified in contracts at all. For example there was no report on provisions that account for a supplier's potential financial distress. In view of the complementarity between the parts, the OEM's interest in an uninterrupted flow of supply, and the high switching cost involved in changing a supplier, it is in the OEM's short run interest to bail-out a current supplier in distress.[9] Also, the OEM may want to enhance competition between suppliers of similar parts by rescuing his present supplier. However, this obviously distorts incentives at the supplier level. Alternatively, under dual sourcing, the second supplier may be asked by the OEM to also produce the distressed supplier's share, towards a gain in reputation against the OEM.[10]

[9] Six suppliers stated explicitly that they observed situations in which the OEM would provide ex post bail-out for suppliers in distress. One supplier declined this. 11 suppliers did not provide an answer.

[10] We have found one instance in which a competitor of the bankrupt supplier was asked by the OEM to provide bailout—thus rescuing the competitor—in exchange for favorable supply conditions on another contract.

Further aspects resulting in contractual incompleteness are borne out in the sequel.

2.3.3 Complexity of parts exchanged

Led by increasing demands on vehicle features such as engine power, energy efficiency, active and passive security, or operating noise reduction, the engineering complexity of vehicles has increased enormously in recent years. This has given rise to the question of delegating development and production of a part rather than producing it in-house. When procuring a part, problems arise from the delegation of control over development and production processes. We have identified three components:

Development complexity arises from the fact that the delegation of development tasks may lead to local rather than global optimization in the development process. This problem is more relevant for parts that are essential for the functionality of, and very much integrated into the structure of the vehicle such as the power train; rather than those that are inessential but with functions that contribute to the vehicle's overall quality, such as the car interior.
The main drivers of development complexity are the essential part's interfaces to other parts and the intensity of required development interactions. One attempt to cope with this complexity problem is to have the supplier's engineers take residence at the OEM's development site. We have found this being common practice during the development phase of essential parts.[11] However, this only partially resolves the problem, since innovation in systems or modules may be driven by suppliers further upstream. In case of the development of a system or module, the system or module supplier has to orchestrate these development efforts.

Logistics complexity is the complexity incurred in the assembly of the system or module, and the scheduling of the assembled parts supply in the specification that is in immediate demand. The logistics complexity is driven by the number of sub- suppliers involved and the complexity of the interfaces between the parts procured by the supplier. For essential parts this interface tends to be very complex. Some of the scheduling problems are accounted for by the establishment of Just-In-Time (JIT) production facilities by the supplier close to the location where the vehicle is assembled.

[11] Out of our interviewees, resident engineer schemes are reported to be used by 7, no interviewee rejected the use of residence engineers, 11 did not respond in this respect

Contract complexity is the complexity incurred by contractual agreements between the business partners, that arises from the outsourcing of more complex parts. It contains the cost of administering business contacts with potential suppliers (including quality certification, etc.) and the actual cost of designing and executing the contract between the OEM and actual suppliers (including the cost of quality control, administration, lawyers, etc.)

Overall the OEMs have reacted to these different forms of complexity by the bundling of parts otherwise procured separately into systems or modules. This should reduce total complexity problems between the OEM and the so-called first-tier supplier. However, the reduction of complexity by increased procurement of systems and modules and systems at the level of the OEM leads to longer supply chains, involving delegated monitoring.

We found two distinct types of system or module suppliers: A first type procures and assembles all parts contained in the system or module independently of the OEM, and delivers it as one part to the OEM. While in this case the OEM enjoys minimum complexity at least for logistics and contracts, he loses the direct contact to the parts suppliers further upstream. The main consequence is a loss of control over the development of the part.

A second type only assembles all the parts, which are procured by the OEM. Whilst only the assembled part is shipped to the OEM such that the logistics complexity for the OEM remains the same as with the first type system supplier, the OEM, by procuring himself, keeps contact to parts suppliers further upstream, at the expense of a higher contract complexity. Hybrids of the two models are common.

2.3.4 Risk and incomplete information

For each part of a vehicle in development, incomplete information of all parties involved creates three major classes of risk that need to be borne by the OEM and its suppliers, namely innovation risk, volume risk, and reliability risk. Portions of all risks are exogenous to the supply hierarchy. For instance, volume risk is to some extent induced by random demand shocks in the downstream car market. However, there are also important endogenous portions. For instance, volume risk is to some extent influenced by the OEM's marketing efforts. In particular, the reliability of the vehicle depends on the effort by many parties in the supply chain that goes into the development (including testing) and the production of all the parts. In view of this the risks need to be allocated between the participants of the supply chain so as to create efficient effort incentives towards controlling these risks. To be more specific, we consider the following components:

Innovation risk is the risk that either an innovation effort fails to achieve an ex-ante stated objective, or the innovation is not achieved at the ex-ante expected cost. Innovation risk differs between model unspecific basic research and model specific adaptation development. Our case study evidence suggests that independent basic research by the supplier constitutes only a small share (about 10 per cent) of his R&D effort. However, the innovation risk involved in this remains fully with him. The larger share of basic research is ordered by the OEM, and sometimes jointly pursued with him in a research joint venture, which reduces the supplier's risk. The remaining share of the supplier's R&D effort constitutes the model specific adaptation of innovation results. While project success is almost sure, the remuneration of project costs is the major risk resting with the developing supplier, if the development costs are reimbursed via a mark up on risky volume. Another kind of innovation risk arises from the fact that final consumers' willingness to pay for a particular innovation embedded in a part may be too low, relative to the cost of producing the innovative part. This risk especially arises when suppliers perform independent basic research, and post development, for the reason given, are faced with the problem that OEMs are not willing to absorb the innovation.

Volume risk is the risk that the realized vehicle sales volume is at variance with the capacity determined on the basis of expected volume. To the upstream supplier the downside risk that volume is below expectations and thus production capacity remains idle carries more financial weight. This risk is exogenous to some extent. However, the OEM's marketing efforts are influential. As car parts are perfect complements to each other, the risk carries over into the supply chain. Supply contracts almost never specify exact quantities. Even minimum quantities to be absorbed by the OEM are rarely specified. However, if specified and the actual numbers fall short of these, the OEM may agree to compensation payments that cap suppliers' risk.[12]

Reliability risk is the risk that parts are subject to a higher than expected failure rate. Additional complexity in the risk involved is due to an important externality. The failure of one part can induce the failure of other parts. An extreme example is the failure of an O-ring that may

[12] That OEMs guarantee minimum quantities is stated by 2 interviewees, 7 reject the use of minimum quantities. Out of the latter, 4 state the possibility of renegotiations when quantities fall short of expectations, but with a strongly varying success rate. 9 interviewees did not respond on this topic.

destroy a car's entire engine. The risk of individual part failure is to a large extent endogenous and varies with the supplier's development and production effort decision. The source of reliability risk cannot always be identified. It is the OEM, however, who is exposed to the quality risk vis à vis the final consumer, typically by a formal warranty commitment, and via reputational effects that may involve indirect costs outweighing by orders of magnitude the direct costs of resolving a warranty problem. Our case study evidence suggests that in the majority of cases failure can be attributed to the faulty part and the supplier is billed the direct cost. Reputational risk, however, remains with the OEM.

2.3.5 Asymmetric information

In upstream markets for buyer-specific parts such as the one considered here, informational asymmetries between OEMs and upstream suppliers take particular forms. By definition, the OEM should know best what suits his business, because that is determined by the final consumer's willingness to pay for the entire vehicle, composed of many complementary parts. By contrast, the supplier knows best the cost of developing and producing the good. More specifically,

R&D effort exerted by the supplier can only be incompletely monitored by the procurer, which invites moral hazard on the supplier side. Joint development efforts, in particular resident engineer schemes, reduce the informational asymmetry. Moral hazard is also contained by the ex post observability of the supplier's R&D success embodied in a vehicle model, that may or may not invite repeated procurement from the same supplier by the same OEM.

Cost information on development and production costs is a key private information of the supplier. During the initial procurement process for a new vehicle model, the OEM can elicit cost information from the competing suppliers; in the extreme form by asking them to reveal their accounting numbers. Since products are idiosyncratic, their production is idiosyncratic, so it requires a specific effort on the OEM's side to uphold, or develop, skills towards evaluating cost structures.[13]

The continued production of parts is subject to substantive learning

[13] One OEM stated that—while fostering outsourcing—he was losing this judging ability due to the loss of technical expertise. Currently he is engaging in measures to stop this drain of expertise.

effects. Towards reducing informational asymmetries in continued procurement phases, the OEMs generate cost estimates first from the internal production of similar parts, as well as with the help of re-engineered parts and a thorough cost analysis. When prices are renegotiated annually under a framework contract, some OEMs organize inverse auctions, often by passing on construction blueprints to competing firms, towards obtaining independent cost estimates. These are often used to press on the incumbent supplier for cost reductions. Recently the OEMs have acquired sufficient market power so that they can require to an increasing extent open book accounting, forcing the supplier to disclose his cost accounting scheme. This can only be profitable for the supplier if either he pursues "creative accounting" in order to hide profits,[14] or if the OEM guarantees him an acceptable profit.[15]

Cost monitoring by the OEM seems more concentrated on more valuable parts.[16] Also, the suppliers feel more squeezed when dealing with a module supplier than with an OEM. Indeed, system and module suppliers also may be forced to disclose their upstream contractual relationships. The OEM may prescribe the upstream partners and impose a particular contractual relationship, via directed business.

Willingness to pay (WTP) by the OEM for a certain procured part is derived, in principle, from the final consumers' willingness to pay for the entire car in the downstream market. Anticipating, and decomposing that willingness to pay into the components supplied is one of the more difficult tasks in the design phase of a car.

The OEM implicitly performs a hedonic price decomposition,[17] and derives his expected benefits by mirroring this with target cost accounting. This cost accounting scheme serves to derive the OEMs WTP for the part.

If a supplier has developed a novel gadget or feature on the basis of his own R&D efforts, he can exploit monopoly power against the OEM buyers. We found that when faced with the alternative to offer the

[14] One supplier, who produces parts as well as the part specific tools, stated that the cost accounting for the tools is much less transparent than for the parts and that tools show significantly higher margins.

[15] Apparently the open accounting scheme was adopted from Toyota, today considered the world's most efficient and profitably vehicle producer. However, Toyota seems to guarantee an acceptable profit (or even profit sharing) in return, whilst this appears not to be done by the German automotive producers.

[16] Statement by one supplier: "Best way to earn money is without attracting attention".

[17] In all cases observed, this is done implicitly by asking the question of How much more would the consumer be willing to pay for the car if the gadget in question were included.

gadget to one OEM towards its monopolistic exploitation in the final market, vs. to offer it more or less simultaneously to several OEMs, he never prefers to offer it to one, but always to several OEMs - possibly after the short term exploitation of monopoly under a short term (six months to one year) exclusivity contract with one OEM. The rationales given are twofold. Most gadgets are produced subject to substantive learning cost reductions, and due to limited enforceability of intellectual property rights, competing suppliers could flood the market with close (improved) product variants.

Expected production volume is an important prerequisite specification for the upstream supplier when determining his production capacity and his unit cost; the latter especially if both the fixed development and the fixed production costs are financed via mark-ups on unit prices. The OEM has an incentive to overstate the expected production volume when negotiating a new contract. Upstream excess capacity would induce a more favorable ex post bargaining situation for him than a capacity shortage, as the supplier's initially quoted per unit mark-ups would be reduced. By our observations, all suppliers anticipate this and determine their capacity by discounting the numbers quoted by the OEM by up to 30 percent.

Generally, by their own statements the players do not consider very important informational asymmetries between first tier suppliers and OEMs. This should lead to relatively low information rents for all players. The OEMs seem to be better informed about the suppliers than the suppliers about OEMs. The OEMs clearly engage actively in measures to reduce the suppliers' private information. Premium and volume OEMs assign differing importance to the individual measures. Premium OEMs are more reluctant in the use of external measures to gain information such as procurement auctions, in order to not curtail suppliers' innovation incentives. Instead, learning from past joint development activities and from procurement with the same supplier seems to be dominant. By contrast, a volume OEM stressed the importance of frequent pseudo-auctions, as well as of re-engineering of parts, as information gathering devices.

2.3.6 Mutual hold-up

Hold-up of the other party could in principle occur in various ways. The OEM faces hold-up risk by the supplier, as by delaying or discontinuing delivery that supplier can bring the entire assembly process to an expensive halt. Additionally, during an ongoing development or production contract, the OEM faces the problem to incentivise the supplier towards exerting effort on improving quality and/or reducing cost.

The supplier in turn faces the problem of potential leakage by the OEM of the intellectual property incorporated into his product, and the risk of not being ordered the volume for which he had designed capacity at a fixed cost. This problem is magnified when the supplier is not fully compensated upfront for his development and production fixed costs. He then is uncertain about the compensation of these fixed costs in the face of uncertain quantities delivered.

Although the OEM very often faces potential hold-up situations with his suppliers we rarely see a supplier actually engaging in hold-up.[18] We found it only in the rare situation in which a supplier not originally under contract for series production was asked to step in, because the original supplier was confronted with quality problems. Conversely the hold up of suppliers by OEMs seems to figure more prominently in two contexts: Some OEMs tend to pass on intellectual property to competitors, or tend to delay payments for delivered parts.

While contractual penalties could remedy the problem, they seem not to play a major role in supply contracts. They also were never mentioned as a strategic option.

2.3.7 Switching cost and lock-in

The production of buyer-, and beyond those, of model-specific parts by a supplier induces switching costs to both the supplier and the OEM. More specifically, switching cost may arise from the following sources:

Product specific intellectual property rights often reside with the upstream supplier. Often there is a generic conflict of interest between the upstream supplier and the OEM. Whilst the OEM would like to exploit such rights by exclusively using the part in his model (or models), the upstream supplier is interested in selling variants of such a part to competing OEMs. No matter the resolution of this conflict, the property right increases the OEM's cost of switching to another supplier of that part. While sometimes the OEM exerts his market power to enforce the licensing of the property right to the supplier's competitors, such an enforcement is invariably related to a loss in the OEM's reputation as a reliable trading partner.

[18] A famous exception is the hold up of Ford by Kiekert, a one time monopolist in the production of car locks, in Wachtler (2002).

Production tools are the product specific elements of a machine to produce a part. For example, the production of a body part necessitates a welding press that can be used to press many different body parts, and a tool that shapes the particular body part. While the welding press is owned by the supplier, the tool is by the OEM in all cases we have observed, but only operated by the supplier. In principle, this enables OEM to withdraw the tool and to set it up with a competing supplier.[19] Yet the cost of reorganizing the supply stream appears so high that this incident arises extremely rarely.

Process know-how complements the use of the tools to produce the car part. It is the capability to manage a particular technology. In most cases this knowledge is technically difficult to transfer, and such a transfer is not enforceable. Together with the tools, the complementing process know-how is idiosyncratic and creates sizeable switching cost to the OEM.

Internal supplier certification on process and product quality as well as on logistics processes by the OEM is costly. Indeed, internal supplier certification costs by the OEM exceed the external process quality certification costs that are the prerequisite for a supplier to participate in a tender at all. When switching suppliers the OEM duplicates these costs. The case study evidence suggests that this is one of the main elements constituting switching cost in a supply relationship.

Capacity that has been built up to supply the parts ordered for one vehicle model typically represents a substantive component of a supplier's total order book. Within a Just-In-Time (JIT) manufacturing scheme the capacity may have been built close to the OEM's manufacturing outlet. This capacity can not be easily relocated or adjusted to the production of other parts, which constitutes the most important switching cost to the supplier.

Production downtime connected with a switch of supplier is also a sizable element of switching cost. Even the transfer of one tool to another supplier inflicts a sizeable loss on the production volume of a vehicle, if, as usual at current production logistics, the OEM does not hold a buffer stock of the part in question.

In all, since the procured parts are complementary to each other, and decreasing cost technologies in development and production invite procurement

[19] It also allows the OEM to indirectly control the markets for spare parts produced with the tool.

from one supplier only, that supplier has, largely due to the switching costs arising for the OEM, an ex post monopoly in the supply of any part that is essential for the production of that vehicle. However, the supplier also faces high short run costs of switching to another buyer.

Both, OEMs and suppliers can strategically influence the level of switching costs. Within limits, the OEM can try to avoid product idiosyncrasies and the associated jeopardy of being held-up. He can engage in industry-wide standardization (e.g. halogen headlights, tires), but this is clearly limited by his interest in specifying unique selling propositions for his vehicle models in the market.

Keiretsu-like structures as used by the Japanese OEM's can also resolve the hold-up problem.[20] The OEM may also employ dual sourcing as a safeguard against lock-in by the first supplier. Yet this option must be weighed against an increase in overall production costs (i.e. double the fixed cost and thus lower economies of scale).

The typical supplier has fewer means to decrease the switching cost for him. By contrast, he can increase the typical OEM's switching costs by increasing the level of intellectual property embodied in the part supplied, so that circumventing the innovation is inefficient and costly for the OEM.

Despite the high switching cost and lock-in potential we rarely see hold-up strategies being played.

2.3.8 Contractual interdependencies

In the automotive market, OEMs produce many models. The suppliers supply parts for many models of many OEMs. This inevitably leads to multi-market-contact between upstream suppliers and OEMs. From our case study, we observe that at any time supply contracts are interdependent, mainly in the following variants:

Supply contracts for innovative and standard products: Many upstream suppliers provide both innovative components and standard commodities to the same OEM. We found evidence that such an upstream supplier appears limited in exploiting monopolistic advantage in the provision of the innovative product. This, he feels, would induce the OEM to withdraw from the supply relationship for more competitive products.

Supply contracts for high and low volume products: Contracts, so the suppliers, differ by volume in their attractiveness to the typical supplier. Large volume contracts appear to be more profitable to the typical

[20] See McMillan (1990) for a description of Keiretsu structures.

supplier than small volume contracts - an indirect indication for the possibility that (portions of) information about decreasing costs remains proprietary to the supplier.
OEMs also offer niche models in small volumes, either because they are profitable themselves, or because there are positive branding spillovers. At any rate, according to our evidence, the OEM demands the supply of small volumes for niche products when contracting with the supplier for large volume products.

There is a third most important variant of contractual interdependence singled out below, namely an intertemporal contractual interdependence.

Contractual interdependencies are virtually always induced by the OEM. Only one premium OEM explicitly stated that he avoids bundling, while focusing on the optimal contract for each part.[21]

2.3.9 Repeated interactions

A particular form of contractual interdependence arises when interactions between the same buyer and seller are repeated many times. Repetitions may arise in the following form:

Repetition within a vehicle model lifetime: There may be sequential contracts on the same vehicle part. Two basic contract types have emerged. One extends over one year, and can be (and in most cases is) extended on an annual basis. The second one, a framework contract, extends over half or the entire model lifetime. However, prices are renegotiated every year, with the option left to either party to discontinue the contract without penalties.[22]

Repetition across several vehicle models: Owing to the OLG structure of model supply, the OEM has to contract anew for structurally the same parts when introducing a new model. The supplier of such a part often remains the same even when the part specification has changed. Our evidence suggests that bargaining about parts supply for a new model is frequently—if not always—used towards renegotiating prices for parts supplied for the production of an established model. The OEM often conditions the award of a new contract to the supplier on an extra price reduction on the old contract. In an exceptional case the supplier

[21] Result from the interviews: Bundling of contracts is common practice (Yes=13, N/A=4, No=1))

[22] Confirmed in 12 interviews

would demand price increases on old contracts in order to agree to a new contract.[23]

2.4 Effects of procurement behavior on the automotive industry: research questions and hypotheses

In this section we specify research questions derived from the evidence obtained, check them against existing theory, and develop hypotheses to be analyzed further theoretically as well as empirically. We distinguish between two types of hypotheses: those related to the efficiency of contracting between the participating (two) parties, and those related to the efficiency of the upstream industry structure that results from the observed contracting structures. In all of this we take as given the OEMs' outsourcing decision.

What is then primarily at stake is the interplay between market pressure and profit incentives exercised on upstream firms to innovate and/or to reduce production costs. These forces exercise impact on magnitudes invariant in the quantity produced (innovation efforts, fixed production costs) and on quantity dependent magnitudes (marginal production costs, that are in turn dependent on fixed costs).

2.4.1 Why does the typical OEM exercise dominant market power in the design and execution (enforcement) of upstream contractual relationships?

One of the most intriguing observations we extract from our case study is that in the relationship between OEMs and first tier suppliers, the larger market power rests with the OEMs, and this in spite of the fact that some of the tier 1 firms are sizeable, and some of the supplier-industries' sectors (defined by product range) at this level are much more concentrated than the automotive producing sector itself. A key example is the automotive electronics subsector, in which until recently three and now two leading global automotive suppliers dominate the market. Apparently, the automotive producers largely set the contracts with these tier 1 upstream suppliers.

This leads us to

Hypothesis 1: The OEM has larger relative market power because he serves - and thus is more knowledgeable about - the final market. In particular, the incorporation of gadgets (developed and) provided by upstream

[23] Result from the interviews: Consecutive contracts are bundled in an OLG structure occurs (Yes=10, N/A=6, No=2)

suppliers is up to the discretion of the OEM, which gives him additional market power.

2.4.2 Is upstream R&D efficiently organized?

Efficient (joint profit maximizing) R&D incentives require that the returns to R&D are fully appropriated by the agent engaging in it.

R&D efforts are reduced if

- they are not fully compensated for
- their beneficiary is not sure about their full value, which induces moral hazard on the seller side
- they act complementarily and are conducted by independent agents, since complementarity induces (uncompensated) positive externalities in increased effort provision.

Hypothesis 2: Upstream innovative efforts are inefficiently small since they are complementary to each other and produced by independent agents, and even smaller

- if the OEM induces competition between innovators and does not compensate their competitive efforts
- if the OEM offers compensation of innovative effort only within a production contract to one of the innovators, and compensation is subject to volume risk.

Hypothesis 3: Incentives to upstream suppliers to invest in both model unspecific R&D and into model specific adaptation are efficient only if effort results are fully internalized, and in particular contractual provisions are such that the use of R&D results can be appropriately licensed out.

A natural conflict arises between the innovative upstream supplier and the OEM with whom he has developed the first application of the innovation. While the latter has an incentive to monopolistically exploit the innovation, the upstream supplier is interested in its multiple application, as multiple applications induce downstream competition and lead to a reallocation of rents to the upstream firm.

Hypothesis 4: Overall efficiency necessitates that R&D results are implemented first in premium models.

Buyers of premium models typically exercise relatively selective tastes for particular vehicle features, and thus exhibit a relatively price inelastic demand. This allows the innovator to recoup his R&D costs with higher probability in a shorter time window, even in a regime where learning cost effects cannot be exploited (as yet).

In order to reduce the complexity of organizing the supply of all parts of a vehicle, the OEMs started in the 90ies of the last century to procure the supply of so called systems and modules. There are two types of system/module suppliers: Systems consist of multiple parts that are functionally connected, modules of physically connected parts. A typical example for a system is the electronics system. A typical example for a module is a car front end. While system suppliers tend to be highly innovative, module suppliers compile and assemble parts from other suppliers often without central innovative features. The latter suppliers thus constitute just another level in the supply hierarchy.

The delegation of system/module development and production implies delegation of responsibilities on

- monitoring innovation in components that form parts of the system/ module in question
- coordination of interfaces between the components
- monitoring the production costs of these components
- administering reliability problems, and absorbing warranty payments.

Hypothesis 5: The vertical flow of innovation is inhibited by the delegation of module or system development and production.

Past work on supply networks, e.g. by Baron and Besanko (1984, 1992, 1994), shows that the existence of asymmetric information could, especially in steeper hierarchies, lead to higher cost for the procurer compared to flatter hierarchies. At best the cost of the organizational form stays constant with the increase of a steeper hierarchy.

In the theoretical literature the profitability of hierarchies is typically assumed. Yet Baron and Besanko (1992, 1994, 1984); Mookherjee and Reichelstein (1997, 2001); Mookherjee and Tsumagari (2004); Melumad, Mookherjee, and Reichelstein (1995) look at the potential cost of hierarchies, which is in the focus of the above discussion on asymmetric information, lock-in, or loss of contact to innovative suppliers in the production chain. Radner (1993); Gruener and Schulte (2004a,b) cover the optimal organization of hierarchies under constrained processing power of the participating units, which can also be related to complexity cost.

2.4.3 Are parts efficiently priced?

By a standard argument, the prices of complementary goods are too high relatively to joint profit maximizing prices if determined independently, since complementarity induces negative externalities from higher prices.

Hypothesis 6: At given levels of innovation, asymmetric information allows upstream producers to set inefficiently high parts prices, especially if upstream markets are concentrated and the OEM is incompletely informed about upstream (innovation and) production costs.

2.4.4 Do contractual interdependences increase the efficiency of supply contracts?

In the world of first-tier supply contracts, contractual interdependences are apparently generated and enforced by the OEMs. A primary driver appears to be the OEM's interest to use his agenda setting power in substituting for informational asymmetry. In the sequel, we consider hypotheses under the assumption that contractual efficiency is defined by the sum of surpluses generated by the two bargaining parties.

Hypothesis 7: The construction of contractual interdependence between supply contracts for innovative and standard parts is efficiency decreasing.

Hypothesis 8: The construction of contractual interdependence between high volume and low volume products is efficiency decreasing.

Hypothesis 9: The construction of contractual interdependence between new and running contracts via price renegotiation in current contracts decreases long run efficiency.

Contracts are incomplete and thus, by now standard arguments (Hart and Moore, 1999; Grossman and Hart, 1986) cannot fully discipline the partners because they give rise to ex post opportunism. Contractual solutions to ex-post opportunism are treated e.g. by Che and Chung (1999), who find that the supplier chooses an efficient investment level only if arrangements are made such that he can at least recoup the initial investment from later payments even after renegotiations. Repeated interactions (eventually infinitely often, or by Kreps, Milgrom, Roberts, and Wilson (1982) discontinuation with low enough probability) can serve as a disciplining mechanism once they involve trigger strategies by the players, thus balancing the incentives for a partner to defect from the agreed contract by offering a high chance of repetition once each contract is honored, and discontinuation otherwise. See also Blonski and Spagnolo (2002).

The upstream supplier's incentives to reduce unit costs are dependent on his ability to absorb the benefits of his cost reducing effort. His preference of a high volume over a low volume contract suggests that the supply of high volumes is more profitable. This must imply that when designing the price decline clauses within a long term contract, the OEM cannot fully anticipate the cost reduction effects due to learning.

If the continued engagement with the same supplier in both R&D and in parts procurement would open channels by which information about cost reduction enjoyed by the supplier were revealed to the OEM as time goes by, then it would be profitable for the OEM, and possibly joint profit increasing, to renegotiate prices.[24] It so far has not become clear whether the price renegotiation frequently enforced by the OEMs is ever due to improved information, or more due to the short term opportunistic use of market power. At any rate, intertemporal contractual interdependencies increase switching costs and, in consequence lead to restricted entry into upstream market.

2.4.5 How do the players cope with mutual hold-up?

Here we assume that hold-up exercised by an agent is observable to the agent subject to.

Hypothesis 10: Hold-up by a supplier is washed out by contractual interdependence, and in particular by repetition.

Hypothesis 11: Hold-up by the OEM via forced price renegotiations is sustainable by pure market power, but inefficient even if suppliers ex ante incorporate it in their calculus.

2.4.6 Does increasing downstream competition reduce upstream innovation and product reliability?

Downstream competition for any particular vehicle type (specified by size and quality) can be thought of as taking place in three major dimensions: Innovativeness, reliability, and price of the vehicle. For any given R&D outlay, there is a trade off between innovativeness and reliability: the more innovations embedded in a new vehicle model, the less these innovations can be exposed to (expensive) test routines. Increasing downstream competition leads to increasing pressure on the downstream sales price for the vehicle, as well as

[24] Meyer and Zwiebel (2006) treat this problem in a theoretical model.

to pressure on time-to-market, the time elapsing between the conception of a new model and its presentation in the market.

The Japanese automotive industry tends to produce competitively priced, reliable vehicles with a lower level of innovation.[25] This allows in particular to use second mover advantages by introducing innovations that are already tested by other players in the market, which also reduces the time-to-market.

One possibility to differentiate that is adopted by European vehicle producers, is to introduce more innovative but, given the limitations on the time-to-market induced by competitive pressure, less reliable vehicles. In view of the pressure on returns and time-to-market, upstream suppliers are simply left with the problem of producing at a given level of innovativeness and a given time-to-market, less reliable parts.

Additional pressure in this direction may be generated by suppliers' opportunism. Innovativeness signals can be profitably exploited in the very short run by the supplier within the upstream competitive context, and by the OEM upon the introduction of a model, whilst reliability problems tend to arise later in the model life cycle, and are largely absorbed by the OEM.

Hypothesis 12: Increasing downstream price competition may lead to reduced product reliability.

2.4.7 Are development, volume, and reliability risks allocated efficiently?

Economic theory suggests that if a certain risk is exogenous, it should be allocated such that the risk neutral party absorbs this risk. By contrast, if a risk is endogenous, the player able to influence this risk according to theory should absorb the payoffs, such that the incentives to manage the risk are optimally set; see, for instance, Tirole (2003).

Let, in line with by now standard reasoning, the degree of risk aversion of the firms in the value chain be directly related to their size, with the OEM as the biggest player being risk neutral.

From a theoretical point of view, the suppliers seem to be allocated an inefficiently high share of volume risk while on the other hand their share of reliability risk seems to be below the efficient level.

Hypothesis 13: If innovative effort primarily rests with the supplier, then he should absorb the associated risk. If the OEM absorbs a share of it, then it should be made dependent on the supplier's degree of risk aversion.

[25] The only exception to this general rule is the hybrid engine car.

We observe that the OEMs take over a share of the fixed production costs of suppliers through financing the OEM specific tools. Yet the larger share of the fixed costs, especially innovation adaptation costs and capacity costs are typically not compensated directly but spread across parts purchased by the OEM. As the OEM rarely provides volume guarantees, this allocates a share of volume risk to the supplier. The OEM typically overstates expected volumes during negotiations, that if used in the supplier's calculation would decrease his expected average cost and make him lenient to a low price offer. However, suppliers anticipate this and typically calculate their offer prices up to 30 percent deflated volume estimates.

From a theoretical point of view, both the exogenous as well as the endogenous proportion of demand uncertainty suggest that it is efficient to have the OEM bear the associated volume risk.

Hypothesis 14: The OEM should bear a larger share of the volume risk than the supplier.

As discussed above there exists a substantial reputation risk, from which the OEM suffers most. This risk can not be transferred to the suppliers, even if the size of the risk stays largely under the influence of the suppliers, for example if the suppliers' effort for quality of specific parts determines the reliability of the whole car.

Hypothesis 15: Reliability risks, including collateral damage, should be allocated to the source as far as possible. Reliability risks involving unobservable sources should be pooled.

2.4.8 Is cost monitoring performed efficiently?

In order to keep production cost down, the OEM might engage into monitoring activities of all parts procured. Cost monitoring involves a large fixed cost component. Hence the OEM has an incentive to allocate more monitoring effort to the production of more valuable, rather than less valuable parts. This incentivizes the supplier to achieve higher cost savings and thus higher margins with lower valued parts. In passing, this has implications on upstream suppliers' relative incentives to supply directly to the OEM vs. to supply to a module or system supplier. He prefers to supply to the former, as the relative value of the same part supplied is the smaller, the more valuable the end product.

Hypothesis 16: Independent of risk premia, supplier margins are inversely related to the relative value of the part. This induces allocative inefficiency.

Suppliers face the risk of bankruptcy, which is partly exogenous, e.g. due to unexpected rises in raw material prices. The allocation of this risk should be corrected in view of the strict ex post complementarities between the upstream supply flows for current production, and in view of the fact that while maintaining a more competitive upstream supply structure is helpful for all OEMs, the individual OEM can internalize only part of this externality. Exogeneity of the causes of financial distress implies that gambling behavior by the upstream supplier is not invited.

Hypothesis 17: OEMs should orchestrate efforts to bail out suppliers if distress is exogenously caused.[26]

2.4.9 Does OEM behavior induce an efficient upstream industry structure?

In a purely price driven competitive situation, an OEM should be interested in more competition at each level in the upstream value chain. This result can be derived from standard auction theory or Cournot oligopoly theory (cf. e.g. Tirole, 2003; Krishna, 2003), where typically the revenue of one side of the market increases with the level of competition on the other side of the market. In this respect the case material apparently confirms the theory. OEMs as well as suppliers stated that a very concentrated upstream market does not allow for a full extraction of profits from the suppliers. One participant stated that two suppliers were not enough to effectively build up price pressure on the supply market.

However, revealed preference suggests that it is at least in some OEMs' interest to restrain competition. Especially premium car manufacturers engage into the practice of assigning core suppliers, to whom they award most of the contacts, thus hoping for a higher degree of innovation and reliability. Yet one premium OEM stated explicitly that together with other OEMs he subsidizes the entry of an additional supplier in a very concentrated market. This strategy was also mentioned by several upstream suppliers. In all, it is unclear whether the optimal level of upstream competition from the OEM's point of view corresponds to an optimal level concerning industry incentives for innovation and reliability.

Hypothesis 18: The assignment of core suppliers by OEMs creates entry barriers and thus an inefficiently concentrated upstream market structure.

[26] One volume OEM explicitly suggested this strategy.

2.5 Concluding Remarks

Our case study interviews focused on a broad range of phenomena in the supply chain of the automotive industry we consider worth further theoretical investigation. We consider interesting in particular questions related to financing innovation including allocative consequences, and the allocation of risks in the value chain.

Several aspects may also be worth a more detailed empirical analysis. Among others, this concerns the pursuit of innovative activities by suppliers, initiated by or connected to particular OEMs. Why is there barely no vehicle model independent research activity of the suppliers? Also, is there a relationship between part type and contract length? In particular, are more complex parts supplied within longer term contracts? And why does module or system outsourcing not emerge as predominant manufacturing organization, given that it apparently leads to tighter cost control?

A question not discussed here relates to the driving forces behind increasing competition in the automotive industry that was assumed in the specification of our hypotheses. One clear sign is that automotive producers' product portfolios have become much more similar during the last ten years. Unless the typical consumer's choice of brand dominates her choice of car size and style, this move observed in the entire industry is bound to lead to increasing competition.

We found systematic excess capacity at the OEM level in need of explanation, less so at the supplier level. Also, changes in the technology of producing automotive vehicles are all towards higher shares of fixed to variable costs. A typical example are ever increasing shares of software in the car. This intensifies questions as to appropriate linear or better, nonlinear pricing schemes.

On a broader scale, one might ask for the OEMs' role model in the automotive industry in the future, given recent and ongoing changes in innovation activities, technology proliferation, and competition intensity. Which activities remain in their generic competence, which ones will, or should be outsourced?

We hope that further work will be able to solve some of the open questions and thus further contribute to bringing together economic theory and empirical findings in one of the major industries in the world.

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2.6 Appendix: Questionnaire

2.6.1 Supplier version

1. Produkteigenschaften

1.1. Teilebeschreibung

1.1.1. Was sind Ihre strategischen Ziele für den betrachteten Produktbereich für die Zukunft? (System- oder Teilelieferant, Know-how Fokussierung)

1.1.2. Welche Produkte (Systeme, Module oder Teile) werden von Ihnen außerdem produziert bzw. eingekauft?

1.1.3. Ist hierbei Ihre Rolle als System- oder Teilelieferant von Beginn an festgelegt oder entscheidet sich dies im Laufe der Entwicklung? Wann entscheidet sich dies im letztern Fall typischerweise?

1.2. Wertschöpfung

1.2.1. Welchen Wertanteil hat das betrachtete Produkt an einem Fahrzeug? Was sind die durchschnittlichen Einkaufskosten und Verkaufspreise für dieses Produkt? Was ist die typische Umsatzmarge?

1.2.2. Welcher Anteil der Wertschöpfung wird vom Systemlieferanten, welcher von dem (den) Teilelieferanten geschaffen?

1.2.3. Inwieweit unterscheiden sich Module/Systeme von Einzelteilen in Produktion und Einkauf hinsichtlich Lernkurven-Effekten (Kosteneinsparung über Zeit; x

1.3. Technologie und Innovation

1.3.1. Wie komplex ist das betrachtete Produkt? Kann es leicht imitiert werden, weil alle Technologien zur Herstellung des Produkts allgemein bekannt sind? Bestehen Patentrechte auf Systeme, Module oder einzelne Teile?

1.3.2. Wie beurteilen Sie die technologische Entwicklung der letzten 5 Jahre im Umfeld Ihres Produktes (insbesondere vor dem Hintergrund einer stärkeren Fokussierung auf Fahrzeugelektronik und Soft- gegenüber Hardware)?

1.3.3. Wie spezifisch für ein bestimmtes Fahrzeugmodell oder einen OEM ist das Produkt in der Entwicklung und in der Produktion?

1.3.4. Wie komplex sind die Schnittstellen (Entwicklung und Einbau) zum restlichen Fahrzeug (Umfang des Lastenhefts, Interaktion mit anderen Bauteilen/Systemen)?
1.3.5. Wie hoch sind die Innovationszyklen im betrachteten Produkt? Wie lange dauert es erfahrungsgemäß, bis eine Innovation auf dem Markt erscheint?
1.3.6. Beschleunigt oder bremst die Vergabe von Modulen/Systemen an Systemlieferanten die Zeit zwischen Entwicklung und Markteinführung eines Fahrzeugs im Vergleich zur Eigenentwicklung durch den OEM?

2. Kunden

2.1.1. Mit welchen Unternehmen unterhalten Sie zu diesem Produkt Lieferbeziehungen?
2.1.2. Welche anderen Produkte liefern Sie außerdem an diese Unternehmen? In wiefern wird die Lieferung verschiedener Produkte (z.B. über Baureihen) oder Projektbündel gemeinsam verhandelt oder bestehen Rahmenverträge?
2.1.3. Welche strategischen Implikationen ergeben sich aus Ihrer Sicht aus der Verbreiterung der Produktpalette durch Fahrzeughersteller, z.B. durch die BMW 1er- und X-Serie, den Porsche Cayenne oder die Mercedes A-Klasse bzw. den Maybach? Wie denken Sie wird dies von den Konsumenten beurteilt?
2.1.4. Wie beurteilen Sie die Bedeutung der Produkteinführungszeiten? Läßt sich eine Tendenz zu kürzeren Produkteinführungszeiten oder -lebenszyklen feststellen und wie wirkt sich diese aus?
2.1.5. Hat sich aus Ihrer Sicht der Wettbewerb zwischen den OEMs erhöht? Was sind Ursachen hierfür (z.B. stagnierende Absatzzahlen, Überkapazitäten, etc.)? Wie hat sich dies gegebenenfalls auf Sie ausgewirkt?

3. Anbieter (im gleichen Produktmarkt)

3.1. Marktstruktur

3.1.1. Wie groß ist der Markt für das betrachtete Produkt in Deutschland, Europa, weltweit (Umsatz, Stückzahlen)?
3.1.2. Wie viele Wettbewerber existieren für das betrachtete Produkt in Deutschland, in Europa, weltweit? In welcher

zeitlichen Reihenfolge erfolgte der Markteintritt Ihres Unternehmens und der Ihrer Wettbewerber?

3.1.3. Wie verteilen sich die Marktanteile unter den angesprochenen Wettbewerbern?

3.1.4. In welchem Umfang hängt die Anzahl der Stufen in der Lieferantenhierarchie ab von der Innovationsfrequenz im betrachteten Markt, der Komplexität des betrachteten Produkts, der Volatilität der Nachfrage nach dem Produkt, dem Wettbewerb im entsprechenden Produktmarkt oder im Fahrzeugmarkt allgemein?

3.2. Anbietereigenschaften

3.2.1. Gibt es technologische Unterschiede zwischen den Wettbewerbern?

3.2.2. Welche Informationen haben Sie über Technologie und Kostenstrukturen Ihrer Wettbewerber?

3.2.3. Was ist Ihre Eigentümerstruktur? Welche Eigentümerstruktur haben Ihre Wettbewerber, Zulieferer und Kunden?

3.2.4. In wieweit hat aus Ihrer Sicht die Entwicklung und Stärkung einer eigenen Zulieferer-Marke, z.B. durch Bosch, Einfluß auf den Wettbewerb unter Zulieferern?

3.3. Globalisierung

3.3.1. Welchen Einfluß hat aus Ihrer Sicht die Globalisierung der Industrie (OEM und Zulieferer) auf den Wettbewerb?

3.3.2. In welcher Form und weshalb verfolgen Sie heute und in der Zukunft eine Globalisierungsstrategie (Zentrale Produktion (High Tech vs. Low cost) und weltweiter Vertrieb vs. Lokale/OEM-nahe Produktion und Vertrieb)?

3.3.3. In wieweit erfolgt eine Produktionsverlagerung gemeinsam mit anderen System- oder Teilelieferanten oder OEMs? Wer führt die Initiative an? In wieweit erfolgt eine (finanzielle) Unterstützung durch andere Unternehmen, insb. den OEM?

3.3.4. In welchem Umfang führt eine Globalisierung der Produktion zu einem verstärkten Wettbewerbsdruck auf Seiten der System- oder Teilelieferanten, z.B. über Second Sourcing?

4. Anbieterauswahl

4.1.1. Wie beurteilen Sie die Auslagerung der Herstellung von ganzen Systemen oder Modulen vom Fahrzeughersteller zu sog. System- oder Modullieferanten und damit die Entwicklung von mehrstufigen Zulieferhierarchien? Worin sehen Sie Vor- und Nachteile einer solchen Entwicklung?

4.1.2. Was sind die wichtigsten Schritte in der Lieferantenauswahl durch Ihre Kunden? Findet eine Auktion (Entwicklung und Produktion) zwischen verschiedenen potentiellen Anbietern statt und wenn ja zu welchem Zeitpunkt in der Lieferantenauswahl?

4.1.3. Wie viele (potentielle) Anbieter stehen dem OEM zu folgenden Zeitpunkten in der Lieferantenauswahl zur Verfügung: Konzeptphase (vor Entwicklung, Entwicklungswettbewerb), während Entwicklung (Parallel Engineering), bei Ausschreibung der Produktion, während der Produktion (Second oder Dual Sourcing) (Wie verteilen sich Aufgaben und Volumina bei mehreren Anbietern gleichzeitig)

4.1.4. Baut der OEM alternative Lieferanten (wenn nicht schon bei einer einzigen Modellreihe) über verschiedene Modellreihen auf?

4.1.5. In wieweit gibt es Vorteile aus wiederholter Zusammenarbeit über verschiedene Projekte hinweg zwischen OEM und Lieferanten? Wie werden diese bei der Vergabe neuer Projekte berücksichtigt?

4.1.6. In welcher Reihenfolge werden Verhandlungen geführt (und ggf. Verträge geschlossen)? Zuerst zwischen OEM und den Systemlieferanten oder zuerst zwischen Systemlieferanten und indirekten Teilelieferanten). Welche Verträge werden zuletzt geschlossen? Wer hat Ausstiegsmöglichkeiten, wann und zu welchen Kosten? Wer bestimmt de Reihenfolge der Verhandlungen?

4.1.7. In welchem Umfang hat der OEM Einfluß auf die Wahl der indirekten Teilelieferanten durch die Systemlieferanten?

5. Entwicklung

5.1. Modellunspezifische Entwicklungen

5.1.1. Können Sie eine Verschiebung der Entwicklungsleistung vom OEM zu System- oder Teilelieferanten feststellen? Wie beurteilen Sie eine solche Entwicklung, wo sehen Sie Vor- und Nachteile?

5.1.2. In wieweit schließen sich Lieferanten untereinander oder mit OEMs bzw. Systemlieferanten für über fahrzeugmodell-spezifische Entwicklungsleistungen hinausgehende Forschung zusammen?

5.1.3. Was sind die wichtigsten Vor- und Nachteile solcher Kooperationen?

5.1.4. Wie wirkt sich dies auf die Lieferantenauswahl und damit ggf. auf Preise aus?

5.2. Modellspezifische Entwicklungen (Adaptionsentwicklungen)

5.2.1. Wie viel Entwicklungsaufwand (Zeit, Mann-Tage, EUR) entsteht durch eine modellspezifische Anpassung (Entwicklung einer bereits prinzipiell bestehenden Technik in ein neues Fahrzeugmodell)?

5.2.2. Welcher Anteil am Entwicklungsaufwand wird vom Teilelieferanten, Systemlieferanten und dem OEM jeweils übernommen (Wer entwickelt und wer trägt die anfallenden Kosten)?

5.2.3. Wer erhält typischerweise Patente an Entwicklungsleistungen?

5.2.4. Wie werden die Aktivitäten der Beteiligten untereinander koordiniert? Wer überwacht die Aktivitäten und definiert Schnittstellen? Wer ist für den Erfolg verantwortlich?

5.2.5. Wie findet bei Entwicklungen durch System- oder (direkten oder indirekten) Teilelieferanten eine Koordination mit Entwicklern anderer Bauteile statt?

5.2.6. In wieweit lassen sich Entwicklungserkenntnisse übertragen und so eine Trennung von Entwicklung und Produktion erreichen? Welchen Anteil am gesamten Entwicklungsaufwand (in Zeit, EUR) müsste bei einer Nach-Entwicklung neu aufgebracht werden wenn Der Erstentwickler den Nachentwickler mit allen vorhandenen Informationen unterstützt, nur eine Übergabe von Zeichnungen und Prototypen erfolgt?

5.2.7. In wieweit kooperieren Sie auch mit direkten Wettbewerbern bei der Entwicklung von Bauteilen, z.B. um Gleichteileffekte bei verschiedenen Fahrzeugen über Baureihen oder sogar Marken hinweg zu nutzen?

5.2.8. Gibt es neben einer Entwicklung durch OEM oder Lieferanten auch eine Entwicklung durch spezielle Entwicklungsfirmen? Wenn ja, wer nutzt solche Firmen vor allem (OEM, Systemlieferant oder Teilelieferanten)? Was sind die Gründe für eine solche Auslagerung von Entwicklungsleistung? Welcher Anteil an Entwicklungsleistungen wird dabei ausgelagert? Wie verteilen sich dabei die Risiken, z.B. falls sich eine Entwicklung als fehlerhaft herausstellt?

6. Produktion

   6.1. Produktionsentscheidungen

      6.1.1. Auf welcher Ebene der Zulieferhierarchie werden welche Entscheidungen getroffen? (z.B. bezüglich Kapazitäten, Produktionsmengen und Losgrößen)

      6.1.2. Nutzt der Lieferant auch Produktionsmittel (Maschinen, Werkzeuge oder auch Patente) des OEM bei der Produktion?

      6.1.3. Rechnen die OEM mit (oder unternehmen die OEM etwas gegen) drohende Insolvenzen der Systemlieferanten oder (direkten und indirekten) Teilelieferanten? Wie hoch ist das jeweils zu erwartende Risiko?

   6.2. Vertragsabweichungen und -strafen

      6.2.1. Wie wollen Lieferanten und OEMs in Zukunft Qualitätssicherung betreiben, um kostspielige Rückrufaktionen zu vermeiden, insb. vor dem Hintergrund einer Verschiebung der Entwicklungsleistung vom OEM zu den System- oder Teilelieferanten?

      6.2.2. Wie und von wem werden Abweichungen von zuvor in Verträgen spezifizierten Kosten, Mengen oder Qualitäten festgestellt? Wie sind entsprechende Strafen vertraglich ausgestaltet? Gibt es außervertragliche Absprachen in dieser Hinsicht?

      6.2.3. Ist es möglich, Fehler im fertigen Produkt System- oder Teilelieferanten zuzuweisen und gegebenenfalls entstehende Zusatzkosten verursachungsgerecht aufzuteilen? Ist es möglich, Fehler des Systemlieferanten im Zusammenbau (im Gegensatz zu den Fehlern der verbauten Einzelteile) des Systems/Moduls zu erkennen?

      6.2.4. Wie häufig sind im Nachhinein zu Tage tretende Missverständnisse in Bezug auf Inhalt und Interpretation von Verträgen?

7. Vertragsgestaltung

   7.1. Vertragsinhalte

7.1.1. Was wird in den Verträgen typischerweise wann spezifiziert? Werden Mengen bereits beim ersten Angebot festgelegt (insbesondere vor der letzten Möglichkeit der Parteien, aus dem Vertrag ohne Vertragsstrafen auszusteigen)?

7.1.2. Wie lange ist die typische Vertragsdauer und wer legt sie fest?

7.1.3. Gibt es selbst noch während der Vertragslaufzeit Nachverhandlungen? Unter welchen Bedingungen finden Nachverhandlungen statt und wer veranlasst diese?

7.1.4. In wieweit wird die Weitergabe von F&E Ergebnissen der Zulieferer an Konkurrenten des OEM vertraglich eingeschränkt?

7.1.5. Welche Absprachen werden neben den vertraglichen Regelungen zwischen OEM und Systemlieferanten bzw. zwischen System- und indirekten Teilelieferanten typischerweise noch getroffen (nicht justitiable Absprachen)?

7.2. Anreizstrukturen und Kostenteilung

7.2.1. In welcher Form und Höhe sind Lieferverträge Performance-abhängig (Zielerfüllung hinsichtlich Qualität und Menge)? Gibt es Unterschiede zwischen den verschiedenen Lieferantenebenen?

7.2.2. In wieweit werden die Kosten für Investitionen des Lieferanten vom OEM (bzw. bei indirekten Teilelieferanten vom Systemlieferanten) übernommen, z.B. für Entwicklungen oder für Maschinen und Werkzeuge?

7.2.3. Wie erfolgt in diesem Fall eine Übernahme der Kosten (direkte Bezahlung, Umschlag auf eine festgelegte Produktionsmenge, etc.)?

7.2.4. Wie wirkt sich eine Kostenübernahme auf die Eigentumsrechte, z.B. an Patenten oder Maschinen und Werkzeugen, aus?

8. Informationen

8.1.1. Welche Informationen hat ein Geschäftspartner (besonders der OEM) über die Produktionskosten der anderen Partner (System- und Teilelieferanten)? In wieweit geben Unterschiede zwischen alten und neuen Produktmodellen oder Baureihen Anhaltspunkte hierfür?

8.1.2. Hat der Systemlieferant bessere Informationen über die Kostenstruktur der indirekten Teilelieferanten als der OEM?

8.1.3. Kann der OEM Informationen oder Vermutungen über die Kosten des Systemlieferanten aus den Verhandlungen mit dem indirekten Teilelieferanten ableiten (falls solche stattfinden)?

8.1.4. Wie flexibel sind Ihre eigenen Informations- und Kostenrechnungssysteme, um verschiedene Vertragskonstellationen abzubilden?

8.1.5. Sind die Verträge zwischen System- und indirekten Teilelieferanten dem OEM bekannt? Wenn ja, welche Elemente (z.B. Preis, Menge, Qualität, Zusammenarbeit in der Forschung)? Kann der OEM Verträge, die er selbst schließt, daran knüpfen?

8.1.6. Sind die Verträge zwischen dem OEM und Systemlieferanten dem indirekten Teilelieferanten bekannt? Kann es z.B. sein, dass der OEM direkt mit dem Teilelieferanten verhandelt und Daten aus dem Vertrag mit dem Systemlieferanten weitergibt?

2.6.2 OEM version

1. Produkteigenschaften

    1.1. Teilebeschreibung

    1.1.1. Was sind Ihre strategischen Ziele im Einkauf für die Zukunft? (z.B. verstärktes Outsourcing, Know-how Fokussierung, mehr oder weniger Zusammenarbeit mit Systemlieferanten)

    1.1.2. Welche Produkte (Systeme, Module oder Teile) bzw. Produktgruppen werden von Ihnen von welchen Lieferanten eingekauft? Wie ist Ihre Einkaufsorganisation aufgebaut? (Weitere Details vgl. Kap. 3)

    1.1.3. Ist hierbei der Einkauf von einem System- oder Teilelieferanten von Beginn an festgelegt oder entscheidet sich dies im Laufe der Entwicklung? Wann entscheidet sich dies im letztern Fall typischerweise?

    1.2. Wertschöpfung

    1.2.1. Welchen Wertanteil am Fahrzeug haben die eingekauften Produkte? Was ist der durchschnittliche Materialkostenanteil, Ihre Wertschöpfung und die Marge je Fahrzeug?

    1.2.2. Welcher Anteil der Wertschöpfung wird vom Systemlieferanten, welcher von dem (den) Teilelieferanten geschaffen?

    1.2.3. Erfahren Sie für Module/Systeme höhere oder niedrigere Economies of Scale relativ zu Einzelbauteilen? In welcher Größenordnung bewegen sich diese (Verdopplung der Einkaufmenge führt zu x Prozent Einsparungen)? In wieweit beziehen diese sich auf die Produktion (Lernkurveneffekte) oder auf Einkaufserfolge (Einkaufs-Economies of Scale)?

    1.3. Technologie und Innovation

    1.3.1. Wie komplex sind die betrachteten, von Ihnen eingekauften Produkte (System, Modul oder Teil)? Sind alle Technologien zur Herstellung dieser Produkte allgemein bekannt? Bestehen Patentrechte auf Systeme, Module oder einzelne Teile?

    1.3.2. Wie beurteilen Sie die technologische Entwicklung der letzten 5 Jahre im Umfeld der von Ihnen eingekauften Produkte (insbesondere vor dem Hintergrund einer stärkeren Fokussierung auf Fahrzeugelektronik und Soft- gegenüber Hardware)?

    1.3.3. Wie spezifisch für ein bestimmtes Fahrzeugmodell oder einen OEM sind die Produkte, in der Entwicklung und in der Produktion?

1.3.4. Wie komplex sind die Schnittstellen (Entwicklung und Einbau) zum restlichen Fahrzeug (Umfang des Lastenhefts, Interaktion mit anderen Bauteilen/Systemen)?
1.3.5. Wie lang sind die Innovationszyklen in den von Ihnen eingekauften Produkten? Wie lange dauert es erfahrungsgemäß, bis eine Innovation auf dem Markt erscheint?
1.3.6. Beschleunigt oder bremst die Vergabe von Modulen/Systemen an Systemlieferanten die Zeit zwischen Entwicklung und Markteinführung eines Fahrzeugs im Vergleich zur Eigenentwicklung (durch den OEM)?

2. Kunden

2.1.1. Welche anderen Unternehmen (OEM) werden vom selben Lieferanten mit dem betrachteten oder einem vergleichbaren Produkt beliefert? Welche OEM kaufen bei anderen Lieferanten ein oder stellen das betrachtete Produkt selbst her?
2.1.2. Welche anderen Produkte beziehen Sie noch vom selben Lieferanten? In wiefern wird die Lieferung verschiedener Produkte (z.B. über Baureihen) oder Projektbündel gemeinsam verhandelt oder bestehen Rahmenverträge?
2.1.3. Welche strategischen Implikationen ergeben sich aus Ihrer Sicht aus der Verbreiterung der Produktpalette durch Fahrzeughersteller, z.B. durch die BMW 1er- und X-Serie, den Porsche Cayenne oder die Mercedes A-Klasse bzw. den Maybach? Wie denken Sie wird dies von den Konsumenten beurteilt?
2.1.4. Wie beurteilen Sie die Bedeutung der Produkteinführungszeiten? Läßt sich eine Tendenz zu kürzeren Produkteinführungszeiten oder -lebenszyklen feststellen und wie wirkt sich diese aus?
2.1.5. Hat sich aus Ihrer Sicht der Wettbewerb zwischen den OEMs erhöht? Was sind Ursachen hierfür (z.B. stagnierende Absatzzahlen, Überkapazitäten, etc.)? Wie hat sich dies gegebenenfalls auf Sie ausgewirkt?

3. Anbieter (im gleichen Produktmarkt)

3.1. Marktstruktur

3.1.1. Wie groß ist der Markt für die von Ihnen eingekauften Produkte in Deutschland, Europa, weltweit: Wie viel Umsatz wird mit diesen Produkten p.a. erzielt? Wie viel Stück werden umgesetzt?

3.1.2. Wie viele potentielle Lieferanten stehen Ihnen für die von Ihnen eingekauften Produkte zur Verfügung? Mit welchen unterhalten Sie Lieferbeziehungen?

3.1.3. Wie verteilen sich die Marktanteile unter den angesprochenen Wettbewerbern?

3.1.4. In welchem Umfang hängt die Anzahl der Stufen in der Lieferantenhierarchie ab von der Innovationsfrequenz im betrachteten Markt, der Komplexität des betrachteten Produkts, der Volatilität der Nachfrage nach dem Produkt, dem Wettbewerb im entsprechenden Produktmarkt oder im Fahrzeugmarkt allgemein?

3.2. Anbietereigenschaften

3.2.1. Gibt es technologische Unterschiede zwischen den verschiedenen System - oder Teilelieferanten im Markt der von Ihnen eingekauften Produkte?

3.2.2. Welche Informationen haben Sie über Technologie und Kostenstrukturen der Lieferanten?

3.2.3. Was ist die typische Eigentümerstruktur eines System- und eines Teilelieferanten: Welche Eigentümer und Gesellschaftsform existiert, in wieweit sind Tochterunternehmen und Beteiligungen vorhanden?

3.2.4. In wieweit hat aus Ihrer Sicht die Entwicklung und Stärkung einer eigenen Zulieferer-Marke, z.B. durch Bosch, Einfluß auf den Wettbewerb unter Zulieferern? Wie beurteilen Sie als OEM den Aufbau einer Zulieferer-Marke?

3.3. Globalisierung

3.3.1. Welchen Einfluss hat aus Ihrer Sicht die Globalisierung der Industrie (sowohl der OEM als auch der Zulieferer) auf den Wettbewerb?

3.3.2. In welcher Form und weshalb verfolgen Sie heute und in der Zukunft eine Globalisierungsstrategie (Zentrale Produktion (High Tech vs. Low cost) und weltweiter Vertrieb vs. lokale Produktion und Vertrieb)?

3.3.3. In wieweit erfolgt eine Produktionsverlagerung gemeinsam mit System- oder Teilelieferanten oder OEMs? Wer führt die Initiative an? In wieweit unterstützen Sie Ihre Lieferanten, z.B. finanziell? In wieweit unterstützen Lieferanten ihre Unterlieferanten bei einer Produktionsverlagerung?

3.3.4. In welchem Umfang führt eine Globalisierung der Produktion zu einem verstärkten Wettbewerbsdruck auf Seiten der System- oder Teilelieferanten, z.B. über Second Sourcing?

4. Anbieterauswahl

4.1.1. Wie beurteilen Sie die Auslagerung der Herstellung von ganzen Systemen oder Modulen zu sog. System- oder Modullieferanten und damit die Entwicklung von mehrstufigen Zulieferhierarchien? Worin sehen Sie Vor- und Nachteile einer solchen Entwicklung?

4.1.2. Was sind die wichtigsten Schritte in der Lieferantenauswahl? Findet eine Auktion (Entwicklung und Produktion) zwischen verschiedenen potentiellen Anbietern statt und wenn ja zu welchem Zeitpunkt in der Lieferantenauswahl?

4.1.3. Wie viele potentielle Geschäftspartner im Systemlieferanten- und (direkten oder indirekten) Teilelieferantenlevel stehen Ihnen typischerweise während der folgenden Phasen zur Verfügung? Konzeptphase (vor Entwicklung, Entwicklungswettbewerb), während Entwicklung (Parallel Engineering), bei Ausschreibung der Produktion, während der Produktion (Second oder Dual Sourcing) (Wie verteilen sich Aufgaben und Volumina bei mehreren Anbietern gleichzeitig)

4.1.4. Bauen Sie alternative Lieferanten (wenn nicht schon bei einer einzigen Modellreihe) über verschiedene Modellreihen auf?

4.1.5. In wieweit gibt es Vorteile aus wiederholter Zusammenarbeit mit einem bestimmten Lieferanten über verschiedene Projekte hinweg? Wie werden diese bei der Vergabe neuer Projekte berücksichtigt?

4.1.6. In welcher Reihenfolge werden Verhandlungen geführt (und ggf. Verträge geschlossen)? Zuerst zwischen Ihnen und den Systemlieferanten oder zuerst zwischen Systemlieferanten und indirekten Teilelieferanten?. Welche Verträge werden zuletzt geschlossen? Wer hat Ausstiegsmöglichkeiten, wann und zu welchen Kosten? Wer bestimmt de Reihenfolge der Verhandlungen?

4.1.7. In welchem Umfang haben Sie Einfluß auf die Wahl der indirekten Teilelieferanten durch einen Systemlieferanten (sog. Directed Business)?

5. Entwicklung

   5.1. Modellunspezifische Entwicklungen

      5.1.1. Können Sie eine Verschiebung der Entwicklungsleistung (vom OEM) zu System- oder Teilelieferanten feststellen? Wie beurteilen Sie eine solche Entwicklung, wo sehen Sie Vor- und Nachteile?

      5.1.2. In wieweit schließen sich Lieferanten untereinander oder mit Systemlieferanten oder Ihnen als OEM für über fahrzeugmodellspezifische Entwicklungsleistungen hinausgehende Forschung zusammen?

      5.1.3. Was sind die wichtigsten Vor- und Nachteile solcher Kooperationen?

      5.1.4. Wie wirkt sich dies auf die Lieferantenauswahl und damit ggf. auf Preise aus?

   5.2. Modellspezifische Entwicklungen (Adaptionsentwicklungen)

      5.2.1. Wie viel Entwicklungsaufwand (Zeit, Mann-Tage, EUR) fällt für ein neues Fahrzeugmodell insgesamt an? Wie teilt sich dieser Aufwand zwischen Grundlagen- und Adaptionsentwicklungen auf? Wie verhält sich dies für einzelne exemplarische (eingekaufte) Teile?

      5.2.2. Welcher Anteil am Entwicklungsaufwand wird vom Teilelieferanten, Systemlieferanten und Ihnen als OEM jeweils übernommen (Wer entwickelt und wer trägt die anfallenden Kosten)?

      5.2.3. Wer erhält typischerweise Patente an Entwicklungsleistungen?

      5.2.4. Wie werden die Aktivitäten der Beteiligten untereinander koordiniert? Wer überwacht die Aktivitäten und definiert Schnittstellen? Wer ist für den Erfolg verantwortlich?

      5.2.5. Wie findet bei Entwicklungen durch System- oder (direkten oder indirekten) Teilelieferanten eine Koordination mit Entwicklern anderer Bauteile statt?

      5.2.6. In wieweit lassen sich Entwicklungserkenntnisse übertragen und so eine Trennung von Entwicklung und Produktion erreichen? Welchen Anteil am gesamten Entwicklungsaufwand (in Zeit, EUR) müsste bei einer Nach-Entwicklung neu aufgebracht werden wenn Der Erstentwickler den Nachentwickler mit allen vorhandenen Informationen unterstützt, Nur eine Übergabe von Zeichnungen und Prototypen erfolgt

5.2.7. In wieweit kooperieren Sie auch mit Wettbewerbern oder Lieferanten von Wettbewerbern bei der Entwicklung von Bauteilen, z.B. um Gleichteileffekte bei verschiedenen Fahrzeugen über Baureihen oder sogar Marken hinweg zu nutzen?

5.2.8. Gibt es neben einer Entwicklung durch OEM oder Lieferanten auch eine Entwicklung durch spezielle Entwicklungsfirmen? Wenn ja, wer nutzt solche Firmen vor Allem (OEM, Systemlieferant oder Teilelieferanten)? Was sind die Gründe für eine solche Auslagerung von Entwicklungsleistung? Welcher Anteil an Entwicklungsleistungen wird dabei ausgelagert? Wie verteilen sich dabei die Risiken, z.B. falls sich eine Entwicklung als fehlerhaft herausstellt?

6. Produktion

6.1. Produktionsentscheidungen

6.1.1. Auf welcher Ebene (OEM, Systemlieferant, Teilelieferant) werden welche Entscheidungen getroffen? (z.B. bezüglich Kapazitäten, Produktionsmengen und Losgrößen)

6.1.2. Nutzen Lieferanten auch Ihre Produktionsmittel (Maschinen, Werkzeuge oder auch Patente) oder die von Systemlieferanten?

6.1.3. Rechnen Sie mit (oder unternehmen Sie etwas gegen) drohende Insolvenzen der Systemlieferanten oder (direkten und indirekten) Teilelieferanten? Wie hoch ist das jeweils zu erwartende Risiko?

6.2. Vertragsabweichungen und -strafen

6.2.1. Wie wollen Sie und Ihre Lieferanten in Zukunft Qualitätssicherung betreiben, um kostspielige Rückrufaktionen zu vermeiden, insb. vor dem Hintergrund einer Verschiebung der Entwicklungsleistung vom OEM zu den System- oder Teilelieferanten?

6.2.2. Wie und von wem werden Abweichungen von zuvor in Verträgen spezifizierten Kosten, Mengen oder Qualitäten festgestellt? Wie sind entsprechende Strafen vertraglich ausgestaltet? Gibt es außervertragliche Absprachen in dieser Hinsicht?

6.2.3. Ist es möglich, Fehler im fertigen Produkt System- oder Teilelieferanten zuzuweisen und gegebenenfalls entstehende Zusatzkosten verursachungsgerecht aufzuteilen? Ist es möglich, Fehler des Systemlieferanten im Zusammenbau (im Gegensatz zu den Fehlern der verbauten Einzelteile) des Systems/Moduls zu erkennen?

6.2.4. Wie häufig sind im Nachhinein zu Tage tretende Missverständnisse in Bezug auf Inhalt und Interpretation von Verträgen?

7. Vertragsgestaltung

7.1. Vertragsinhalte

7.1.1. Was wird in den Verträgen typischerweise wann spezifiziert? Werden Mengen bereits beim ersten Angebot festgelegt (insbesondere vor der letzten Möglichkeit der Parteien, aus dem Vertrag ohne Vertragsstrafen auszusteigen)?

7.1.2. Wie lange ist die typische Vertragsdauer und wer legt sie fest?

7.1.3. Gibt es selbst noch während der Vertragslaufzeit Nachverhandlungen? Unter welchen Bedingungen finden Nachverhandlungen statt und wer veranlasst diese?

7.1.4. In wieweit wird die Weitergabe von F& E Ergebnissen der System- oder Teilelieferanten an andere OEM vertraglich eingeschränkt?

7.1.5. Welche Absprachen werden neben den vertraglichen Regelungen zwischen Ihnen und Systemlieferanten bzw. zwischen System- und indirekten Teilelieferanten typischerweise noch getroffen (nicht justitiable Absprachen)?

7.2. Anreizstrukturen und Kostenteilung

7.2.1. Hängen die Gewinne der Firmen, die direkt an Sie liefern, stärker von ihrer Performance (Zielerfüllung hinsichtlich Qualität und Menge) ab? Beinhalten z.B. die Verträge zwischen Ihnen und Systemlieferanten einen höheren pauschalen Anteil und die Verträge zwischen System- und indirekten Teilelieferanten einen höheren produktionsmengenabhängigen Anteil?

7.2.2. In wieweit werden die Kosten für Investitionen der Systemlieferanten oder Teilelieferanten von Ihnen übernommen, z.B. für Entwicklungen oder für Maschinen und

Werkzeuge? Übernehmen Systemlieferanten solche Kosten bei den Teilelieferanten?

7.2.3. Wie erfolgt in diesem Fall eine Übernahme der Kosten (direkte Bezahlung, Umschlag auf eine festgelegte Produktionsmenge, etc.)?

7.2.4. Wie wirkt sich eine Kostenübernahme auf die Eigentumsrechte, z.B. an Patenten oder Maschinen und Werkzeugen, aus?

8. Informationen

8.1.1. Welche Informationen haben Sie über die Produktionskosten und Gewinne Ihrer Geschäftspartner (System- und indirekten Teilelieferanten)? In wieweit geben Unterschiede zwischen alten und neuen Produktmodellen oder Baureihen Anhaltspunkte hierfür?

8.1.2. Hat der Systemlieferant bessere Informationen über die Kostenstruktur der indirekten Teilelieferanten als Sie?

8.1.3. Können Sie Informationen/Vermutungen über die Kosten des Systemlieferanten aus den Verhandlungen mit dem indirekten Teilelieferanten ableiten (falls solche stattfinden)?

8.1.4. Werden von System- oder Teilelieferanten Preismenüs (z.B. verschiedene Möglichkeiten der Kompensation von Entwicklungskosten) angeboten? Wie transparent sind diese Kalkulationen?

8.1.5. Sind Ihnen die Verträge zwischen System- und indirekten Teilelieferanten bekannt? Wenn ja, welche Elemente (z.B. Preis, Menge, Qualität, Zusammenarbeit in der Forschung)? Können Sie Verträge, die Sie selbst schließen, daran knüpfen?

8.1.6. Sind die Verträge zwischen Ihnen und dem Systemlieferanten den indirekten Teilelieferanten bekannt? Kann es z.B. sein, dass Sie direkt mit dem Teilelieferanten verhandeln und Daten aus dem Vertrag mit dem Systemlieferanten weitergeben?

3. ASYMMETRIC PROCUREMENT MECHANISMS

3.1 Introduction

3.1.1 Motivation

The automotive industries in Europe, North America and Asia are facing similar tasks and incentives in their procurement process. Indeed they procure comparable parts with lots in the same order of magnitude. Yet the pattern of procurement evolved differently in large parts. At first glance, the Asian car producers largely engaged in a protective long term contract model. Alike forms exist throughout many economies of East Asia. As Dyer (1996) showed, a key element of this system is strategic development of the suppliers to build mutual knowledge of the production processes and shared profit from the achieved benefits of cooperation. Other evidence suggests a downside interpretation, with highly demanding car producers, exercising high pressure onto the suppliers without using the market. The European and North American car industry instead relied on frequent competitive auctions amongst potential suppliers in the quest for extracting benefits from contracting with the most efficient supplier.

While this difference may largely be rooted in industry history and business culture, one should ask whether there are deeper trade-offs between the two procurement mechanisms and what factors drive the decision amongst them. This question takes on further importance by the observations of Liker and Choi (2004), that western car producers recently try to imitate their Asian counterparts.

In general the procurer needs to balance the trade-off between setting the right incentives for an incumbent to invest in relationship-specific investments on the one hand and exerting competitive pressure in order to profit from competitively bid down procurement prices on the other hand. As Hahn, Kim, and Kim (1986) already point out, these goals are conflicting as higher competitive pressure and thus a higher probability of losing the incumbency status lowers the incentive of the incumbent to invest. We will analyze this trade-off in a theoretical model and subsequently we will return to an empirical case study on the automotive industry to qualify our results. Moreover we will use results from the case study to derive the model structure and some assumptions.

3.1.2 Existing work

Laffont and Tirole (1988) address this problem in a two period model with an incumbent investing in the first period to lower his production cost in the second period, in which he competes with a potential entrant. They show that in the resulting asymmetric auction the procurer should favor the weaker (higher cost) firm, if the investment of the incumbent is not transferable to the entrant. These results are obtained with an objective function from the view of a regulator, which might differ from profit maximizing behavior of a firm.

Dasgupta (1990), Tan (1992), and Bag (1997) build onto this two-period model and introduce competition at the investment stage. As the investment can be undertaken by all contestants, it takes the shape of general R&D expenses rather than relationship-specific investments. They examine underinvestment with symmetric firms under several auction formats partially with reserve prices and entry fees. Arozamena and Cantillon (2004) show underinvestment in the first price auctions if only one firm has the option to invest and investments are observable to the other firms.

Acknowledging the rare use of entry fees in practice, Bag (1997) gives also an example where a bid-discriminating second-price auction performs better than both fair first- and second price auctions under endogenous investment decisions. The example suggest discrimination in favor of the stronger (lower cost after investment) firm as this induces higher incentives to invest. This discrimination stands in contrast to the results of previous research by McAfee and McMillan (1989) and Laffont and Tirole (1988). The result of McAfee and McMillan (1989) in the context of international trade is driven by exogenous differences in cost distributions rather than endogenous differences due to investments. In the work of Laffont and Tirole (1988) the advantage of the investment, if it is non-transferable, accrues solely to the incumbent and improves his cost position in the second period, such that the weaker firm should be favored by the procurer.

3.1.3 This contribution

We analyze an infinitely repeated procurement setting for an indivisible product from the view of a procurer. He can choose to either award the contract again to the incumbent of the previous period or to one out of several entrants. The suppliers are symmetric but for the incumbent's ability to invest in relationship specific assets before the tender procedure. The investment structure is most similar to the one in Arozamena and Cantillon (2004). The investment advantage of the incumbent can be reinterpreted as switching cost (i.e. cost disadvantage on the side of the potential entrant), which are sizable, as Greenstein (1995, 1993) shows, and can typically to a large extent be influenced by the incumbent supplier. We are interested in the effects of repeated transactions, but unlike Laffont and Tirole (1988) we consider infinitely repeated interactions to abstract from last round effects, which could arise in a two-period model. We model advantages that the procurer might want to grant to the incumbent via the procurer's option to use a more or less asymmetric sequential procurement mechanism.

We compare two specific procurement mechanisms, which are derived from stylized facts of existing procurement processes from the case study results. They differ in the timing of events and thus the procurer's information structure:

> In the *Competitive Mechanism*, the procurer first solicits bids from the competitive group of entrants to learn about his best alternative option, before challenging his previous incumbent to match the entrants' best offer.[1]
>
> In the *Protective Mechanism* on the other hand, the procurer makes a posted price offer to the incumbent and refrains from the auction and the resulting information in the first place. He only uses the market, if the incumbent declines the offer in order to search the entrants for an alternative supplier.

To see the information and timing aspect of the two mechanisms more clearly we need to stress that negotiations generically consist of two steps: first the procurer generates an option, on which he decides in a second step. These two steps can be chronologically separated. In the *Competitive Mechanism* the option generation with the entrants takes place in the beginning, but the procurer's decision is delayed until he makes the offer to the incumbent. This improves the procurer's information about his alternative option and thus his bargaining position, when negotiating with the incumbent as compared to the *Protective Mechanism*. Here the procurer generates the option with the incumbent in the beginning and immediately decides on this option before eventually entering option generation with the entrants, such that the negotiation with the incumbent can not improve his bargaining position anymore.

We first solve for the equilibria in both mechanisms. Subsequently, we analyze the superiority of the mechanisms. We single out the analysis of bids and of the investment levels. Afterwards we combine all effects and discuss the procurer's choice of one of the mechanisms depending on properties of the investment.

We find the *Competitive Mechanism* to be superior concerning the resulting payments to the procurer, supporting the intuition, that CM exercises

[1] The offer made to the incumbent needs not to be exactly equal the entrant's offer. It can be chosen freely by the procurer, but it may condition on the best entrant's bid, which will be optimal.

higher market pressure via the better information position of the procurer. Concerning investment the superiority results are mixed: For low investment cost, CM also induces the higher investment. Else, PM induces higher investments, but is limited in the absolute maximum level. In the total comparison, we show by the use of examples in the investment cost space, that none of the mechanisms is generally superior.

Our analysis touches three main economic problems: First, the hold-up problem due to the investment that binds the buyer to the incumbent. Second, the asymmetric information problem concerning the production cost and thus the problem of the buyer to elicit this information via an auction. And third, the relevance of infinite repetition and the influence of future periods on the behavior in the period in question.

3.1.4 Organization of the paper

The main part of the paper is organized as follows. In section 3.2 we introduce the two mechanisms to be compared and solve for the equilibria in section 3.3. In section 3.4 we compare the two mechanisms and obtain the main results. Before we conclude in the last section, we qualify our results against case study observations and suggest some extensions.

3.2 The Model

The model features three types of players: One procuring firm P, one incumbent supplier I and $N \geq 2$ entrant suppliers E1,…,EN, with a generic entrant Ej. Players interact in every period of a repeated stage game. In every period, P needs to procure exactly one unit of an indivisible good, to which he attaches value w, high enough to make procurement efficient at all production costs. w is assumed to be common knowledge. Each supplier has private information about his production cost c_{Ej} (c_I respectively) for the good. In order to make computations and results better comparable to those in standard auction theory and monopoly theory, we introduce the suppliers' types $\theta_{Ej} = w - c_{Ej}$ ($\theta_I = w - c_I$ respectively) as the suppliers' valuation for the procurement contract. Thus θ_{Ej} describes the total benefits of cooperation between the procurer and a specific supplier E_j and is private information to this supplier. This allows us to interpret the procurer as *seller* of a procurement contract and the suppliers as potential *buyers*, such that we can analyze the problem in a standard sales setting. We normalize the types θ on the support $[0, 1]$ and assume them to be independently distributed according to a distribution $F(\cdot)$.

Concerning the tender of the contract, we will compare two different procurement mechanisms for the stage game. Both feature a simultaneous first-price auction amongst the entrant suppliers and an offer from the procurer to the incumbent supplier. They differ in the order in which the auction and the offer to the entrant take place and at which point in time the procurer makes a decision to choose one supplier. Consequently they also display a different information structure. We explain the differences of the mechanisms in detail in sections 3.2.1 and 3.2.2 after presenting further commonalities.

We call entrant Ej's bids for the procurement contract in the auction B_{Ej} and the offer made to the incumbent B_I, hence if the contract is sold and all payments for the contract as well as for the procurement transaction are made, the supplier gets a payoff of $w - c_{Ej} - B_{Ej} = \theta_{Ej} - B_{Ej}$ (or $w - c_I - B_I = \theta_I - B_I$ respectively) and the procurer obtains the bid B_{Ej} (or B_I). Like in the normal sales setting, the seller doesn't know about the valuation of the buyers, the buyers bid for resulting payments to the seller, the winning buyers gets a payoff of his valuation minus his bid, and the seller lets the highest bidder win.

We assume all suppliers to be symmetric up to the incumbent having the possibility to make a relationship-specific investment $i \in \mathbf{R}_+$ at cost $C(i)$ at the beginning of each stage game. Note that the identity of the incumbent is endogenous in the repeated game. The investment generates an additional value of i to the procurer if he awards the contract to the incumbent again in the current period.[2]

All actions are observable. In particular, we assume that the entrants know the investment choice of the incumbent when bidding in an auction.[3]

Thus we get the following ex-post payoffs for the one period stage game

[2] In reality, relationship-specific investments benefit typically the procurer as well as the incumbent. As the procurer observes the benefits of the investment, it doesn't matter, whether they accrue to the incumbent or the procurer. The procurer has always the possibility to post a take-it-or-leave-it offer to the incumbent that elicits the total observable benefit.

[3] This model fits an industry that is established and concentrated enough to allow for this assumption. Procuring for a non-commodity, specialized good, that incorporates sizable incumbency advantages, is typically done in a very narrow market with rich information flows between the players. Dropping this assumption and introducing beliefs about the investment gives us multiple equilibria. One belief system entails correct presumptions and contains the equilibrium considered here.

to the incumbent, the entrants and the procurer:

$$u_I = \begin{cases} -C(i) + \theta_I - B_I & \text{if P sells to incumbent I} \\ -C(i) & \text{if P sells to an entrant} \end{cases}$$

$$u_{Ej} = \begin{cases} \theta_{Ej} - B_{Ej} & \text{if P sells to entrant E}j \\ 0 & \text{otherwise} \end{cases}$$

$$u_P = \begin{cases} B_I + i & \text{if P sells to incumbent I} \\ B_{Ej} & \text{if P sells to entrant E}j \end{cases}$$

We employ Markov perfect equilibrium as solution concept to the repeated game.

As motivated above, we can now explain the differences in the two procurement mechanisms within the stage game, before getting to the repetition of the stage game, which concludes the model description of the game we are to analyze in the subsequent sections.

3.2.1 Competitive Mechanism (CM)

In the Competitive Mechanism (CM), the procurer first holds an auction amongst the entrants and then issues an offer to the incumbent. Thus we have the resulting timing as follows:

(1) The incumbent chooses an *investment* $i \in \mathbf{R}_+$ at cost $C(i)$.

(2) Nature draws the valuations of this period's procurement contract for all suppliers as *private information* $\theta_I, \theta_{E1}, \ldots, \theta_{EN}$.

(3) The procurer initiates a *first-price auction* amongst the entrants E1,..., EN in which they submit bids $B_{E1}, \ldots, B_{EN} \in \mathbf{R}_+$. The winner of this auction obtains the contract—and has to pay his bid—only if the incumbent rejects a take-it-or-leave-it offer from the procurer in step (4).

(4) The procurer, knowing the bids of the entrants, issues a *take-it-or-leave-it offer* B_I to the incumbent. The incumbent accepts ($d = 1$) or rejects ($d = 0$).

The *competitive mechanism* is characterized by the procurer trying to execute as much direct pressure on the incumbent as possible by first investigating what alternative option he can get from the entrants and then using this information against the incumbent. This mechanism is derived from the practice of European and North American car producers.

3.2.2 Protective Mechanism (PM)

On the other hand, we have the *protective mechanism (PM)*. Here the key difference is that P forgoes learning his actual outside option before making a (binding) offer to I. This is modelled by interchanging the order of the auction in step 3 and the take-it-or-leave-it offer in step 4. Only if the the offer to I is declined, an auction amongst the entrants takes place. The payoff functions and the assumptions remain the same. Thus we get the following timing for PM:

(1) The incumbent chooses an *investment* $i \in \mathbf{R}_+$ at cost $C(i)$.

(2) Nature draws the valuations of this period's procurement contract for all suppliers as *private information* $\theta_I, \theta_{E1}, \ldots, \theta_{EN}$

(3) The procurer issues a *take-it-or-leave-it offer* B_I to the incumbent. The incumbent accepts ($d = 1$) or rejects ($d = 0$).

(4) Only if the incumbent rejects, the procurer initiates a *first-price auction* amongst the entrants E1,. . . , EN in which they submit bids $B_{E1}, \ldots,$ $B_{EN} \in \mathbf{R}_+$. The winner of this auction obtains then the contract.

The *protective mechanism* is characterized by the procurer granting incumbency advantages to the incumbent and trying to execute not so much direct pressure. By committing to delay the search for an alternative option, the procurer relieves direct market pressure from the incumbent and makes the incumbency status more valuable, which executes indirect market pressure via the threat of losing the incumbency. This mechanism is derived from the practice of Asian car producers as well as from the practice of highly innovative European premium car producers in the case study.

3.2.3 Repetition of the stage game

We extend these stage games into an infinitely repeated game, in order to exclude last period effects.[4] All players discount future periods with a common discount factor $\delta \in (0, 1)$. Types are independently drawn each period for each supplier. The analysis of type-correlations over time in the repeated game is not covered in this paper and can be worthwhile to examine in a separate effort.

We do not allow for switching mechanisms between periods. This is to capture long lasting and reliable industry standards that predominate in

[4] Due to the formulation with continuation values, this model can be extended to a finitely repeated version of the game with last period effects.

the industry-wide supply structure for one specific product. So in order to compare the two models we let the procurer announce upfront one or the other model.

We adopt Markov Perfect Equilibrium (cf. Fudenberg and Tirole, 2000) as solution concept, such that all future payoffs beyond the payoff of the current stage game can be expressed using continuation values. These depend only on the payoff relevant information of the current period for future periods, the so called exit state. The state in this model can be captured in one variable and is the identity of the winner of the contract, i.e. the incumbent in the next period. We denote the continuation value of the next period's incumbent and entrants by V_I and V_E respectively. The procurer's continuation value is V_P.

Thus, payoffs of the repeated game for incumbent I, an entrant Ej, and procurer P are as follows:

$$\begin{aligned} U_I &= \begin{cases} -C(i) + \theta_I - B_I + \delta V_I & \text{if I wins, i.e. } d = 1 \\ -C(i) + \delta V_E & \text{if an entrant wins, i.e. } d = 0 \end{cases} \\ U_{Ej} &= \begin{cases} \theta_{Ej} - B_{Ej} + \delta V_I & \text{if E}j \text{ wins, i.e. } d = 0 \text{ and } B_{Ej} \text{ is highest bid} \\ 0 + \delta V_E & \text{otherwise} \end{cases} \\ U_P &= \begin{cases} B_I + i + \delta V_P & \text{if I wins, i.e. } d = 1 \\ B_{Ej} + \delta V_P & \text{if E}j \text{ wins, i.e. } d = 0 \text{ and } B_{Ej} \text{ is highest bid} \end{cases} \end{aligned}$$

with the continuation values being $V_P = \mathbf{E}[U_P]$, $V_I = \mathbf{E}[U_I]$ and $V_E = \mathbf{E}[U_E]$. The continuation values capture the discounted expected stream of future payoffs if the players enter the next period in the roles that are specified by the exit state of the current period. Thus $\delta(V_I - V_E)$ is the advantage of being the next period's incumbent discounted to the current period.

In the repeated game, all players maximize their discounted stream of current and future profits. For Markov perfect equilibria, the analysis of the infinitely repeated game collapses to the analysis of a steady state in the stage game with continuation values. Due to the information structure of the game, we can use a backward induction procedure to solve for equilibria of the full game. Thus, an equilibrium in both mechanisms is defined by a tuple $(i^*, B^*_{Ej}, B^*_I, d^*)$ of the value i^* and the functions B^*_{Ej}, B^*_I, d^*. All optimization problems condition on the observed actions of the preceding steps, which are different for CM and PM according to the timing.

In the following analysis, it will be helpful to have expressions for the bids of the entrants and the offer to the incumbent net of the incumbency advantage. Therefore we introduce the notation $b_I := B_I - \delta(V_I - V_E)$ and

$b_{Ej} := B_{Ej} - \delta(V_I - V_E)$.[5] In the upcoming sections we will use either notation for bids according to the ease of reading.

3.3 Equilibria

In this section we derive the equilibria of the two mechanisms before we get to the comparison results in the next section. We provide interpretations mostly in the results section to keep this discussion short and avoid unnecessary repetitions.

In order to derive the equilibria of both mechanisms, we first need some regularity assumptions on the distribution of the suppliers' valuations $F(\theta)$.

Assumption 1: $F(\theta)$ is thrice continuously differentiable with strictly positive density function $f(\theta)$ on the support $[0,1]$. The hazard rate $h(\theta) := f(\theta)/(1-F(\theta))$ of $F(\theta)$ is increasing and the reverse hazard rate $r(\theta) := f(\theta)/F(\theta)$ of $F(\theta)$ is decreasing.

Assumption 1 is valid throughout the whole analysis. We will add other assumptions where needed in the course of the discussion. These will be purely technical and do not allow for an ostensive description of the distributions that fulfill the assumptions. The uniform distribution of types $F(\theta) \sim U[0,1]$ fulfills all assumptions made in this paper.

Moreover we need some notation. In the following we use $b_E = \max_j b_{Ej}$ and $B_E = \max_j B_{Ej}$ to indicate the highest of the N entrants' bids and $\theta_E = \max_j \theta_{Ej}$ as the highest of the N entrants' types. Hence, θ_E is distributed according to the highest order statistic of N independent draws from the distribution of types $F(\theta)$, i.e. $\theta_E \sim F(\theta)^N$.

3.3.1 Competitive Mechanism

We solve the game backwards by first analyzing the offer to the incumbent and his acceptance decision. Then we proceed to the bids of the entrant and finally we describe the optimal investment behavior of the incumbent.

Proposition 1 (Offer to incumbent and acceptance in CM):

Let $v(b_I) := b_I - \frac{1-F(b_I)}{f(b_I)}$ be the virtual valuation function[6].

[5] Note that these values will in equilibrium clearly differ for the two mechanisms. In the comparison results we indicate the values with ^{C} and ^{P} for the Competitive and the Protective Mechanism respectively. We omit the index if the context is unambiguous or the expression is equally valid for both mechanisms.

[6] We use the virtual valuation function $v(\cdot)$ as defined by Bulow and Roberts (1989). The allocation in an optimal auction as well as the optimal price setting in monopoly can be described with the help of this virtual valuation.

Given some investment i and a maximum bid from the entrants b_E, in any equilibrium in the CM, the procurer's offer to the incumbent and I's response to this offer must be of the following form:

$$b_I^* \begin{cases} = 0 & \text{if } b_E \leq i - \frac{1}{f(0)} \\ = v^{-1}(b_E - i) & \text{if } i - \frac{1}{f(0)} \leq b_E \leq i+1 \\ \in [1, \infty) & \text{if } i + 1 \leq b_E \end{cases}, \quad d^* \begin{cases} = 1 & \text{if } \theta_I > b_I \\ \in \{0,1\} & \text{if } \theta_I = b_I \\ = 0 & \text{if } \theta_I < b_I \end{cases}$$

The proof is given in appendix 3.8.

Remember that the offer is the part of the total benefits of the procurement contract, that will stay with the procurer, such that a higher offer increases the procurer's payoff, if the incumbent accepts the offer. On the other hand a higher offer decreases the probability, that the incumbent accepts the offer, and accordingly the chance for the procurer to profit from the investment. If the highest bid from the entrants is too low (i.e., $b_E \leq i - \frac{1}{f(0)}$), then the procurer wants to realize the benefits from the investment and makes an offer to the incumbent, which he accepts for sure ($b_I = 0$). If the highest bid from the entrants is higher than the sum of the investment and the highest possible valuation of the incumbent(i.e., $i + 1 \leq b_E$), then the procurer wants to select the entrant for sure ($b_I \geq 1$).

Next we can solve for the equilibria of the auction amongst the entrants. In general the auction amongst the entrants is a symmetric standard auction with a monotonically downward shifted winning probability. The winning entrant only wins the contract, if the offer induced by his winning bid is declined by the incumbent. This risk of not winning is the same for all entrants, observable, and needs to be taken into account when bidding in the auction. The entrants anticipate that higher bids increase the probability that the procurer will issue an offer to the incumbent, which he will decline more often, increasing the entrants winning probability. This leads us to a description of the entrants' bidding behavior.

Proposition 2 (Bids of the entrants in CM): The equilibrium bid function $b^*(\theta)$ in CM possesses the following properties:

a) For $\theta \leq \max\{0, i - 1/f(0)\}$, $b^*(\theta) \leq \theta$ and can be chosen arbitrarily.

b) For $\theta > \max\{0, i - 1/f(0)\}$,
$b^*(\theta)$ is strictly increasing, continuous, and differentiable almost everywhere with $\lim_{\theta \downarrow \max\{0, i-1/f(0)\}} b^*(\theta) = \theta$.
For all θ where the first derivative $\dot{b}^*(\theta)$ exists, it is defined by

$$\dot{b}^*(\theta) = \frac{(N-1)r(\theta)}{\frac{1}{\theta - b^*(\theta)} - \frac{r(v^{-1}(b^*(\theta)-i))}{v'(v^{-1}(b^*(\theta)-i))}} \tag{3.1}$$

A proof is given in appendix 3.8.

In the subsequent analysis we are only interested in integrals of $\dot{b}^*(\theta)$. Thus we can compute them using (3.1) and neglecting the fact that $b^*(\theta)$ is only differentiable almost everywhere.

The optimal bids for low types $\theta \leq \max\{0, i - 1/f(0)\}$ can be chosen arbitrarily weakly below the type, as these bids have no chance of winning. If these types would bid higher, they had a chance of winning, but would incur negative payoffs, thus entering any bid, that has no chance of winning is optimal. Thus we have the optimal bids of the entrants strictly increasing in the type and the bid of the lowest type $\theta > \max\{0, i - 1/f(0)\}$ approaching his type.

We were not able to prove one additional property of the entrants' optimal bid function b^*, which we will need in the comparison results section. The bids of the entrants should react to the investment level in a way that a higher investment also leads to more aggressive bids, but that this reaction does not exceed the increase in the investment. This leads us to a conjecture and a line of reasoning to support the conjecture.

Conjecture: $\dfrac{db^*}{di} \in (0, 1)$

A higher investment raises the value for the procurer of contracting again with the incumbent. He will therefore lower his offer and increase the incumbent's winning probability. The entrants see this monotone decrease of their expected payoffs and will answer with an increase in bids $db^*/di > 0$, to partially offset the decrease in winning probability with a decrease in the payment in the case of winning the contract. This increase in the expected bids will lead to a higher offer. We know that the optimal offer depends positively on the difference $b^* - i$, such that an increase in b^* with $db^*/di > 1$ would even lead to a higher offer and thus to a decrease in the incumbent's winning probability. We conjecture that, if this was optimal for the entrants, then it would have been optimal from the beginning and would lead to a contradiction. Thus the adverse reaction of the entrants' optimal bids to an increase in the investment must be positive and less than proportional. Numerical computations suggest, that the conjecture holds at least for $N = 2$ entrants and uniform distribution of types.

Using proposition 1 on the offer to the incumbent and proposition 2 on the bids of the entrants, we can investigate the allocation of the contract for a certain realizations of types and a given investment level i. This will allow us to compare the allocation in the two mechanisms to each other and to the efficient allocation in section 3.4.

The incumbent accepts the equilibrium take-it-or-leave-it offer if

$$\theta_I \geq v^{-1}(b^*(\theta_E) - i) \iff \theta_E \leq b^{*-1}(v(\theta_I) + i) \tag{3.2}$$

We use the notation

$$s(\theta_I|i) := b^{*-1}(v(\theta_I) + i)$$

for the function separating the regions in the (θ_I, θ_E)–diagram in figure 3.1 with the incumbent's valuation on the horizontal axis and the best entrant's valuation on the vertical axis. We need to distinguish two cases for higher and lower investments.

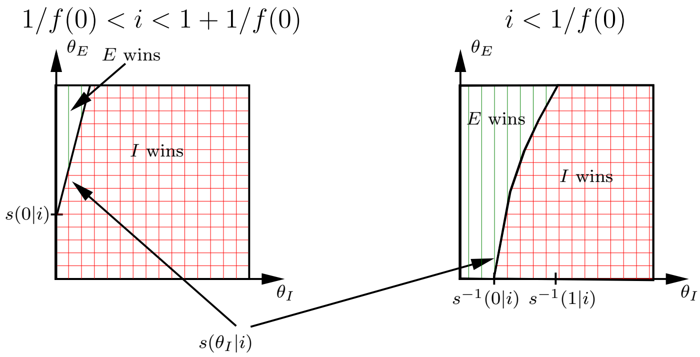

Fig. 3.1: Contract allocation over type combination in CM

For type combinations on the right of s, the incumbent obtains the procurement contract whereas to the left of the line the highest type entrant obtains the procurement contract, given some level of investment i. One can interpret this resulting combined mechanism of the offer and the auction as one non-standard-auction[7] which implements the allocation rule represented by s depicted in the graph.

Finally we can proceed to the optimal investment by the incumbent. In order to discuss the optimal investment, we calculate the expected revenue of the investment for the incumbent:

[7] In this auction the entrants have a first-price payment rule, whereas the incumbent has a second price payment rule with a correction relative to the bid. The highest bidder wins the auction.

Proposition 3 (Investment in CM):
Let the function **I** be an indicator function, that is defined as turning 1, if its condition is fulfilled and turning 0 otherwise.[8]

Then the revenue from investment i in CM

$$R(i) := \mathbf{E}[\mathbf{I}_{d^*=1}(\theta_I - B_I^* + \delta V_I) + \mathbf{I}_{d^*=0}\delta V_E]$$

is increasing for $i \in [0, 1 + \frac{1}{f(0)})$, and constant for $i > 1 + \frac{1}{f(0)}$.

A proof is given in appendix 3.8.

The revenue from investment increases with i if the investment is below a certain threshold level. Above this level, the investment is so valuable to the procurer that he will make an offer to the incumbent, which I will never reject. A higher investment only benefits the procurer even more, but is of no use to the incumbent.

3.3.2 Protective Mechanism

Similar to CM, we derive the equilibrium properties in the Protective Mechanism and start backwards with the bids of the entrants in the auction, if the incumbent has declined the offer:

Proposition 4 (Bids of the entrants in PM):
The equilibrium bid function $b^*(\theta)$ in PM satisfies the condition

$$b^*(\theta) \begin{cases} = \frac{\int \theta dF(\theta)^{N-1}}{F(\theta)^{N-1}} & \text{for } \theta > 0 \\ \leq 0 & \text{for } \theta = 0 \end{cases}$$

The procurers expectation about the highest bid of the entrants is given by

$$\mathbf{E}[b_E^*] := \int_0^1 \frac{\int \theta dF(\theta)^{N-1}}{F(\theta)^{N-1}} dF(\theta)^N.$$

A proof is given in appendix 3.8.

If in the Protective Mechanism the auction amongst the entrants takes place, the incumbent must have declined the offer. Thus the auction is a symmetric standard first-price auction amongst the entrants with the known

[8] Thus we have for example

$$\mathbf{I}_{d^*=1} = \begin{cases} 1 & \text{in the cases for which } d^* = 1 \\ 0 & \text{in the cases for which } d^* \neq 1 \end{cases}$$

properties. The lowest possible type will never win and bid his type. Higher types will bid monotonically higher, but they will shade their bids to be lower than their types.

Next we can solve for the acceptance behavior of the incumbent and the optimal offer from the procurer to the incumbent. This step is structurally similar to proposition 1 for the Competitive Mechanism. However, now the procurer doesn't have an actual alternative option from the entrants, but an expectation about his alternative option in the subsequent auction, if the incumbent declines his offer. Thus the expected best bid $\mathbf{E}[b_E^*]$ replaces the actual best bid b_E in the procurer's optimization problem.

Proposition 5 (Offer to incumbent and acceptance in PM):
Given some investment i, P's offer to I and I's response to this offer must be of the following form:

$$b_I^* \begin{cases} = 0 & \text{if } \mathbf{E}[b_E^*] \leq i - \frac{1}{f(0)} \\ = v^{-1}(\mathbf{E}[b_E^*] - i) & \text{if } i - \frac{1}{f(0)} \leq \mathbf{E}[b_E^*] \end{cases}, \quad d^* \begin{cases} = 1 & \text{if } \theta_I > b_I \\ \in \{0,1\} & \text{if } \theta_I = b_I \\ = 0 & \text{if } \theta_I < b_I \end{cases}$$

A proof is given in appendix 3.8.

Compared to the considerations in the Competitive Mechanism, we can omit the case for the expected best bid of the entrants exceeding the sum of the investment and the potential best type of the entrant, as this will never be reached.

Again, with the incumbent's acceptance decision we can depict which supplier wins for which combination of types in figure 3.2 on the same axes as in figure 3.1.

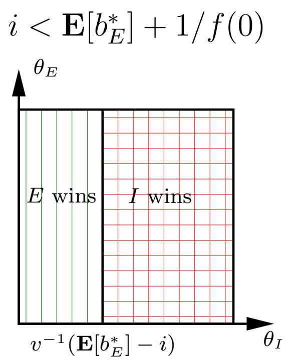

Fig. 3.2: Contract allocation over type combination in PM

Here the incumbent's acceptance decision conditions on the procurer's offer as in the Competitive Mechanism. Yet the offer can only condition on the expected best type of the entrants, rather than the actual best type. Thus the allocation must be independent from the actual type of the best entrant and the separation function in the (θ_I, θ_E)–diagram is a vertical line. If the investment is bigger than the adjusted expected best bid $\mathbf{E}[b_E^*] + \frac{1}{f(0)}$, then the procurer makes an offer to the incumbent that he will never reject.

Like in CM, the last property covers the incumbent's revenue from investment:

Proposition 6 (Investment in PM):
The revenue from investment in PM

$$R(i) \quad := \quad \mathbf{E}[\mathbf{I}_{d^*=1}(\theta_I - B_I^* + \delta V_I) + \mathbf{I}_{d^*=0}\delta V_E]$$

is increasing for $i \in [0, \mathbf{E}[b_E^*] + \frac{1}{f(0)})$ and constant for $i > \mathbf{E}[b_E^*] + \frac{1}{f(0)}$. Furthermore, $R(i)$ is concave for $i \in [0, \mathbf{E}[b_E^*] + \frac{1}{f(0)})$ if $v''(x)/v'(x) \geq -h(x)$.

A proof is given in appendix 3.8.

Again the revenue from investment is increasing in i until the investment induces an offer from the procurer to the incumbent, such that the incumbent accepts for sure. Above this threshold further increases in the investment are not profitable to the incumbent supplier anymore.

3.4 Comparison results

In order to answer the question for the procurer's choice of one or the other mechanism and—more importantly—the determinants of this choice, we derive results on the comparison of the two mechanisms with respect to bids and investment. We will merge these results into a partial preference result from the view of the procurer. Furthermore we show the implications for the expected length of business with the same supplier and the frequency of market interactions.

3.4.1 Utility of the procurer

As we center our analysis around the decision of the procurer we first examine his payoff structure and the causal effects that drive his decision. These are equally valid for both CM and PM, so we can omit to index the functions and we abbreviate the entrants' equilibrium bid function to b^* for the ease of reading.

The procurer's expected profit in equilibrium can be written as

$$\begin{aligned}\mathbf{E}[U_P^*] = & \underbrace{\mathbf{E}[\mathbf{I}_{d^*=1}(b_I^*(\theta_I)+i^*)+\mathbf{I}_{d^*=0}b^*(\theta_E)]}_{\substack{\text{P's expected present period revenue}\\ \text{net of payments made for the incumbency advantage}}} \\ & + \frac{\delta}{1-\delta}\Bigg[\underbrace{-C(i^*)+\mathbf{E}[\mathbf{I}_{d^*=1}(\theta_I+i^*)+\mathbf{I}_{d^*=0}\theta_E]}_{\text{expected per period pie size}} \\ & -(N+1)\underbrace{(1-\delta)\mathbf{E}[U_E^*]}_{\substack{\text{expected per}\\ \text{period rent of}\\ \text{an entrant}}}\Bigg]\end{aligned} \tag{3.3}$$

with

$$\mathbf{E}[U_E^*] = \frac{1}{1-\delta}\frac{1}{N}\mathbf{E}[\mathbf{I}_{d^*=0}(\theta_E - b^*(\theta_E))]$$

The first element is the procurer's expected present period revenue net of payments made for the incumbency advantage. He gets the offer b_I^* and the investment i^*, if the incumbent wins, and the bid b^*, if an entrant wins. The second and the third term represent the part of procurer's expected rent that is related to business in future periods, allocated on a discounted per period basis. Herein the second term is the total expected pie (= sum of all distributable rents) in each period, which is the incumbent's valuation θ_I and the investment i^*, if I wins, and one entrant's valuation θ_E, if an entrant wins. To get the net pie size, the investment cost $C(i^*)$ needs to be deducted. Due to his bargaining power, the procurer can extract all rents in the future except the continuation value of an entrant for each of the $N+1$ players in the game, incumbent or entrant, as each player can replicate this payoff by intentionally losing the contract. So overall the procurers expected utility in the long run is the larger the larger the total pie and the lower the minimum value he must leave with an entrant.

By inserting the condition for $\mathbf{E}[U_E^*]$, we get the procurer's expected equilibrium payoff in an infinitely repeated game. For sufficiently high values of δ only the value of the future periods in the last bracketed expression in (3.3) is important, i.e.

$$-C(i^*)+\mathbf{E}[\mathbf{I}_{d^*=1}(\theta_I+i^*)+\mathbf{I}_{d^*=0}\theta_E] - \frac{N+1}{N}\mathbf{E}[\mathbf{I}_{d^*=0}(\theta_E - b^*(\theta_E))]. \tag{3.4}$$

In contrast, we get the procurers expected payoff in a one period game by the first expression in (3.3). Hence the procurer sees two different maximization problems in a short-term or long-term perspective. In the short-term he cares about the extraction of bids from all suppliers. In the long term perspective he cares about the tradeoff between efficiency and the share of the pie he is forced to leave over for the other players.

Expression (3.4) allows us to see directly the influence of policy changes in the contract allocation, the bids, and the investment onto the utility of the procurer, which will be useful in the following analysis. We will first analyze the behavior of the bids and the investment and derive conditions for their behavior. These will help us in assessing the mechanism choice of the procurer by his expected utility.

3.4.2 Bids

In the following sections we compare the equilibria induced by the two considered mechanisms. Hence we index with $^{\mathrm{C}}$ and $^{\mathrm{P}}$ for the Competitive and the Protective Mechanism respectively to point out differences.

At a given investment level i^*, in CM the types below a certain threshold can't issue a bid, such that they make positive profits as shown in proposition 2. Any—potentially profitable—bid below the type leads to a winning probability of zero, any bid above the type could lead to a positive winning probability, but can never be profitable. For all types above the threshold, we find that the direct competitive pressure is indeed higher in the Competitive Mechanism than in the Protective Mechanism: the bids of each type are higher in CM than in PM.

Proposition 7 (Bids):
For any investment levels i^{P} and i^{C} and any type $\theta \in (\max(0, i - 1/f(0)], 1 + 1/f(0)]$, bids in CM are more aggressive than in PM:

$$b^{*\mathrm{C}}(\theta|i^{\mathrm{C}}) \geq b^{*\mathrm{P}}(\theta|i^{\mathrm{P}}).$$

A proof is given in appendix 3.10.

The intuition for this result is clear, if we compare the general structure of the auction part of the two mechanisms. In PM we have a symmetric first price auction amongst N bidders. Whereas in CM we have the same auction but there is a certain probability that the incumbent will win the contract at a fixed price offer, such that the entrants effectively play against each other and additionally against another player with a distorted payment rule, which causes more aggressive bids.

Note that Proposition 7 is valid for arbitrary—potentially different—investment levels in CM and PM. This implies that it is also true for the respective equilibrium investment level $i^{*\mathrm{P}}$ and $i^{*\mathrm{C}}$. If in the Protective Mechanism the entrants get to bid in the auction, they know that the incumbent must have declined the offer before. Thus the investment payoff can never be payed out to the procurer and will not influence his decision. Thus it must not influence the bids of the entrants and their bidding behavior is comparable to a setting where the investment is always zero. In the Competitive Mechanism, however, a positive investment will lead to more aggressive bids of the entrants, as they are playing against a better alternative option. furthermore we have effectively one further player in the auction, which also increases the aggressiveness of their bidding behavior, such that we obtain our result for arbitrary investment levels.

As described in section 3.4.1, we allocate all payments to the period that causes the respective payment. Remember, that the observed bid in one period B_{Ej} is constituted by the payment part for the current period b_{Ej}, which is analyzed above, and a payment that values the incumbency advantage for the future periods. The latter part could contribute to the utility of the procurer only via future rent extraction from the other players, which we will include in the final analysis. Allocating the payments correctly, we know from the objective function in (3.4), that the procurer profits from higher bids b_{Ej} of the entrants. When comparing the full bids B_{Ej}, the relation $B^{*\mathrm{C}} > B^{*\mathrm{P}}$ need not to hold, due to the rent extraction part, which could for PM exceed the lag concerning bids. If the procurer discounts the future a lot (δ very small) and we have effectively a one period game, then the future part tends to zero and B_{Ej} converges against b_{Ej}.

3.4.3 Investment

In order to compare the optimal investment in the equilibria of CM and PM, we need to fix a space of cost functions. We make statements for the space of cost functions of second degree polynomials with zero fixed costs:

Assumption 2: $C(i) := c_1 i + c_2 i^2$ with $(c_1, c_2) \in \mathbf{R}^2_+ \setminus \{(0,0)\}$.

This clearly restricts the scope of our analysis, but buys us the structure to derive meaningful results for some more questions. Restricting the space of cost functions in this way is purely technical and should not be too restrictive as it includes a class of cost functions with constant as well as decreasing returns to investment.

As seen in the previous section, the optimal investment in each of the mechanisms is bounded from above and weakly decreases in investment cost. We compare the two mechanisms by their upper bounds and the ability to induce investment below these maximum levels.

Proposition 8 (Investment):

a) The maximum of the optimal investment is larger in CM than in PM, i.e.

$$i^{*\mathrm{C}}_{\max} := \max_{c_1,c_2} i^{*\mathrm{C}} = 1 + \frac{1}{f(0)} > i^{*\mathrm{P}}_{\max} := \max_{c_1,c_2} i^{*\mathrm{P}} = \mathbf{E}[b^{\mathrm{P}}_E] + \frac{1}{f(0)}$$

b) For all investment cost parameters c_1 and c_2 such that $i^{*\mathrm{C}} < i^{*\mathrm{P}}_{\max}$, we have $i^{*\mathrm{C}} < i^{*\mathrm{P}}$.

Conversely, for all investment cost parameters c_1 and c_2 such that $i^{*\mathrm{C}} > i^{*\mathrm{P}}$, we have $i^{*\mathrm{P}} = i^{*\mathrm{P}}_{\max}$.

Part b) is valid, if two technical conditions on the distribution function of types, $F(\theta)$, hold:

$$\frac{v''(x)}{v'(x)} > -h(x) \tag{3.5}$$

and for $i \geq 0$

$$\frac{1 - F(v^{-1}(\mathbf{E}[b^{*\mathrm{P}}] - i))}{v'(v^{-1}(\mathbf{E}[b^{*\mathrm{P}}] - i))} \geq \mathbf{E}[\frac{1 - F(v^{-1}(b^{*\mathrm{P}} - i))}{v'(v^{-1}(b^{*\mathrm{P}} - i))}] \tag{3.6}$$

A proof is given in appendix 3.10.

For a fixed set of investment cost parameters c_1 and c_2, at which the optimal investment level in CM ($i^{*\mathrm{C}}$) is below the maximum investment in PM ($i^{*\mathrm{P}}_{\max}$), we have that the optimal investment in CM is always also below the optimal investment in PM. Conversely, for a fixed set of cost parameters, the investment in CM can only exceed the investment in PM, if the investment in PM is at its upper bound.

The investment behavior might appear counterintuitive at first. With the protective mechanism, the procurer intends to protect the incumbent from direct market pressure and to induce indirect market pressure with the threat to chose an entrant, if the incumbent declines the offer. At higher investment cost, the incumbent can in fact make himself more attractive to the procurer by increasing the investment. However, the procurer must take into account, that at very low investment cost, the direct market pressure in the competitive mechanism works better, as the incumbent in the protective mechanism can not be driven to higher investments, if he is already fully protected from the competition.

The optimal investment behavior in a (c_2, i^*)-plane for $F(\cdot)$ being uniformly distributed and $c_1 = 0$ can be displayed in a schematic diagram in figure 3.3.

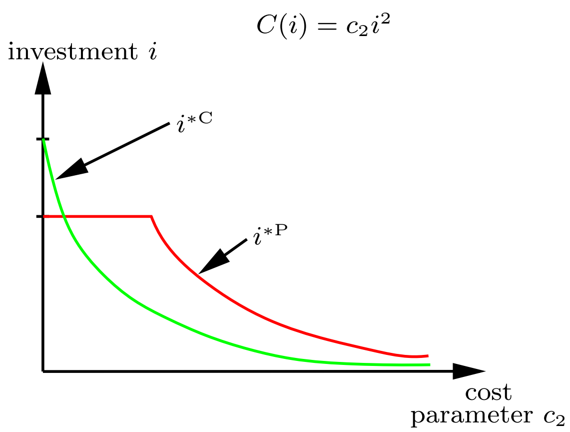

Fig. 3.3: Optimal investment comparison between CM and PM

At very low investment cost c_2, where investment in PM has already reached its maximum level, the optimal investment in CM exceeds the level in PM. For higher investment cost, the Protective Mechanism is able to induce higher investments.

We can examine the mechanics behind the investment in more detail. Given the limited commitment and the incomplete transferability of utility in the model, investment can only be driven by the transfer of utility from the procurer to the incumbent via the offer. The incumbent will invest—transfer utility to the procurer— as long as the procurer is willing to compensate him by lowering the offer, i.e., transfer winning probability from the entrant to the incumbent. This only works as long as the incumbent doesn't win for sure, i.e., at an offer $b_I^* > 0$. Hence, investment never exceeds an upper bound, even if the investment cost become very low.

The maximum investment level is reached earlier in the Protective Mechanism, as in PM I wins for sure, if he is sufficiently better than the expected alternative option of the procurer—the expected highest bid of the entrants. Whereas in CM, where the procurer knows the bid of the best entrant before he makes the offer, I invests with less information than the procurer has when making the offer. Thus to win for sure in CM he has to be sufficiently better than the best alternative option the procurer might have, rather than the expected average alternative option.

Before the investment in the Protective Mechanism reaches its upper bound, it always displays higher levels than in the Competitive Mechanism. The CM provides the incumbent with a lower marginal return of investment: An increase in the investment in the CM can be observed by the entrants. To preserve their probability of winning against the incumbent, they respond with more aggressive bids. This in turn induces a higher offer from the procurer due to a better alternative option. This higher offer lowers the incumbents marginal revenue from investment. The procurer can not commit, not to use the better information from the alternative option. This adverse response to the increase in the investment can not be present in PM by the timing of events.

Finally, the assumptions in the statement in Proposition 8b need some qualification. The statement holds if $(1 - F(x))/v'(x)$ is decreasing, which is assumption (3.5) and if it is "not too convex". The admissible degree of convexity depends on quantitative properties of b^{*C}, which we cannot compute explicitly. To obtain a purely technical condition we have to rely on a broad estimate instead and propose assumption (3.6). It holds for example, if for a distribution function we have that $(1 - F(x))/v'(x)$ is concave. This condition holds for distribution functions that do not have too much weight on the extremes. Especially it holds for $F(\cdot)$ being uniformly distributed.

3.4.4 Mechanism choice

In the previous sections we have shown, that concerning the bids, the procurer prefers the Competitive Mechanism, and concerning the investment he prefers the Protective Mechanism for high and medium investment cost and the Competitive Mechanism for low investment cost. In this section we can combine these results and add implicitly the willingness of the suppliers to pay for the incumbency status advantage in future periods. This effect can turn around the results and we show that there are in fact points in the investment cost space for which the Competitive Mechanism produces higher bids as well as a higher investment, but the procurer still prefers the Protective Mechanism.

In general the combination of the single effects turns out to produce complex combined effects, such that a complete characterization of the procurer's choice of mechanisms for every point in the cost space needs to remain open in this analytic approach. However, we can identify points in the cost space, where we can derive the superiority of one or the other mechanism, that show that not one of the two mechanisms dominates the other for all cost parameters. Thus we can conclude, that the procurer's choice of a procurement mechanism should depend on the specific characteristics of the part procured, rather than preferring a single mechanism throughout the whole portfolio of parts.

In the following proposition we identify points in which the procurer prefers one or the other mechanism. Subsequently we give some intuition on the results.

Proposition 9 (Mechanism Choice): If δ is sufficiently close to one, then there exist cost parameters where the procurer prefers PM to CM, and there exist cost parameters where the reverse holds.

In particular, we can identify the following points:

(I) At cheap investment, CM induces a so much higher investment such that P prefers CM over PM.

(II) If there are sufficiently many entrants, at medium expensive investments there exist points with equal investment, where we have $i^{*\mathrm{P}} = i^{*\mathrm{C}} = i^{*\mathrm{P}}_{\max}$ in which P prefers PM over CM.

A proof is given in appendix 3.10.

As the combination of all single effects can lead to complex total effects, we can make clear statements best for points in the cost parameter space where either one effect turns less important. Especially helpful is the identification of points in the cost space, where investment cost are unimportant—either because they are very low (as for point (I)) or because they are equal in PM and in CM (as for point (II)). Recalling the procurer's objective function in equation (3.4), we see that for these cases P's preference for either one of the mechanisms hinges only on two things: efficiency of the contract allocation, which maximizes $\mathbf{E}[\mathbf{I}_{d^*=1}(\theta_I + i^*) + \mathbf{I}_{d^*=0}\theta_E]$, and the rent he has to leave to the players. Thus we can restrict the preference analysis for these points to an assessment on the efficiency of the allocation and the entrants' expected rents. The first is maximized if the contract is awarded to the player with the highest valuation, corrected for the investment. In a (θ_I, θ_E)–diagram the efficient allocation is determined by a 45-degree-line shifted upwards by the investment level i^* as displayed in figure 3.4. Above this line it is efficient if the highest valuation entrant obtains the contract, below this line it is efficient if the incumbent wins the contract again.

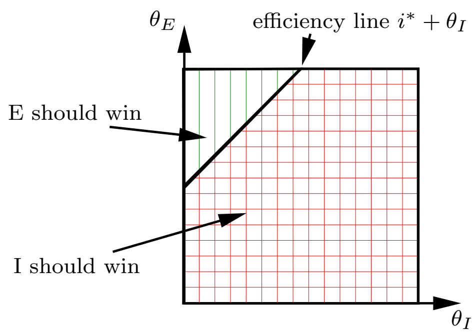

Fig. 3.4: Efficient contract allocation

If the investment from the incumbent exceeds the best possible type of the entrants, the line is shifted all the way up into the corner and the only efficient allocation is, if the incumbent wins always.

The second expression for the rent the procurer has to leave with the other players, $-(N+1)/N \cdot \mathbf{E}[\mathbf{I}_{d^*=0}(\theta_E - b^*(\theta_E))]$, increases with the entrants' bids and decreases with the probability for an entrant to win the contract. Thus the procurer will be able to extract higher rents from the players, if he chooses the mechanism, that induces the highest bids of the entrants and that lets them win less often, as both render the status of an entrant less attractive and allow higher rent extraction from the incumbent via indirect market pressure.

With the help of the considerations in the previous paragraphs, we can provide some intuition for proposition 9. At very low investment cost—for point (I)—both mechanisms CM and PM induce such a high investment level that the procurer lets the incumbent win with a probability arbitrarily close to one. By Proposition 8 the investment level in CM is higher than in PM. As in both mechanisms the entrants have a payoff of arbitrarily close to zero and investment costs are negligible, only the efficiency part of expression (3.4) is relevant. The higher investment renders CM better.

The existence of point (II) hinges on two conditions. First, the allocation rule of the contract is closer to the efficient allocation in PM than in CM. And second, the entrants obtain a smaller rent in PM than in CM.

To rank the allocation in the two mechanisms, we need to find the efficient allocation first. For a high number of entrants the expected best bid of the entrants approaches 1 from below. For sufficiently low investment cost we know that the optimal investment reaches 1 in both mechanisms. Thus, the efficient allocation is reached, if the incumbent wins the contract for sure.

At a point of equal investment we know from proposition 8 that only in the protective mechanism the incumbent wins for sure, whereas in the CM the entrants have a non zero probability of winning the contract. Thus the protective mechanism is at this point clearly more efficient.[9]

The same line of reasoning also shows that the payoff of an entrant in the CM must be higher, as he has a probability to win bigger than zero in the CM, rather than no chance of winning in the PM. So the procurer favors the Protective Mechanism concerning both effects discussed, he is neutral concerning the investment and overall he favors the Protective Mechanism.

Note especially, that since point (II) is at cost parameters which induce equal investment, there are also a region of cost parameters around (II) with slightly higher investment in CM. By proposition 7 bids are also unambiguously higher in CM. Nevertheless the procurer prefers PM in the repeated game due to the strictly better allocation as discussed above. In a one period game, that does not consider payments for the incumbency status in the future, the procurer would prefer CM to PM. The rent extraction for future periods turns this result and renders PM better. This behavior is provoked by the incumbent's bigger fear to lose the contract and become an entrant next period in PM than in CM. Therefore P is able to extract a higher rent from the incumbent in PM. This effect exceeds quantitatively the higher bids and investment in CM.

With the continuity of the functions underlying these considerations we conjecture, that the behavior that prevails at the points can be extended to regions around these points, that ultimately span the cost space. However already from the existence of the two points we can conclude, that the procurement mechanism should be different according to the properties of the parts procured and no one mechanism dominates the other for the whole cost space.

3.4.5 Supplemental remarks

Before we conclude we briefly discuss some interesting supplemental remarks—without providing proof—about the two mechanisms, that we can derive from the insights above, and which we can relate to the case study evidence in the next section.

[9] Note that Point (II) exists for *arbitrary* distributions of types as long as we have a sufficiently high number of entrants N. There are always constellations of cost parameters for which the incumbent in PM already wins for sure, whereas in CM sometimes an entrant wins and this result does not depend on the distribution assumptions of Proposition 8.

Repetition

As discussed in the introduction, infinite repetition of a stage game is rarely used in this literature so far. In this model we show that some results are invariant to the repetition. Some others in fact depend on the repetition or the way in which repetition is modelled.

In this model we can see, that the optimal investment level and the expected pie size (= sum of all players' rents) in CM and in PM is independent of the repetition of the game. However, the division of the pie amongst the players, and thus the procurer's preferences over the mechanisms, depends on the repetition. If we change the number of repetitions it is ambiguous, whether a specific player's rent increases or decreases.

Thus, if one is interested in situations of repeated procurement in which players are not aware of a final procurement period, modelling the game as being infinitely repeated seems more accurate than considering a once repeated game.

Shortlist

The superiority of the protective mechanism relies on the procurer's ability to commit not to use the better information about his alternative option. Similarly we could think of situations in which the procurer profits from commitment to restrict the number of entrants considered in the auction, as this also intentionally deteriorates his alternative option.

In the model we see, that there exist combinations of cost parameters at which P prefers to restrict the number of entrants in PM. Simple examples for these effects can be obtained by considering P's utility from PM as function of the number of bidders N for the case with uniformly distributed types.

Typically procuring companies recruit possible suppliers only from a predefined list of suppliers that fulfill a certain quality standard. Given this fixed cost of maintaining a potential supplier on the list, this result can easily be obtained. In our model this behavior holds without the introduction of additional costs, purely out of reasons inherent to the procurement choice.

3.5 Empirical evidence

This paper was developed in the context of broader research on supply networks in the automotive industry. One centerpiece is a series of deep case interviews with suppliers and car manufacturers on their strategic supply and purchasing behavior.[10] The authors interviewed 15 suppliers and three car manufacturers on questions concerning the parts supplied, the organization of purchasing, the supply strategies, the information about other players in the market, the contractual arrangements, and the competitive situation. We draw on the empirical evidence of this case study to comment on the assumptions and results of the theoretical model.

In the automotive industry, the structure of one incumbent and multiple entrant suppliers is very common. The incumbency advantage due to idiosyncratic process knowledge is sizeable. A switch from one supplier to another is legally possible without complications, as the manufacturer mostly owns the tools to produce the parts. Adversely, in practice switching is very expensive, as the tools are complemented with very specific process knowledge, that can not easily be replicated by a new supplier. Thus the switching cost constitutes the bigger part of the incumbency advantage. Furthermore the resulting level of switching cost is endogenous and can be set by the incumbent, as displayed in this model. Furthermore the case study suggests, that modelling infinite repetition of a stage game is adequate. The manufacturers as well as the suppliers are long-lived and the possible interactions should not induce end game behavior. In the same sense also the commitment to a certain purchasing strategy is long-term. The purchasing strategy only becomes effective (concerning its implications for the suppliers' long-term innovation strategy) if the OEM can build up reputation for a certain strategy. Thus we model long-term strategies concerning the choice of a purchasing mechanism specifying the order of bargaining stages. In contrast, the case study shows evidence for a widely opportunistic behavior of all players in the short-run. Consequently we set up the model without ex-ante commitment on decisions within the stages, i.e. price setting and acceptance decisions on contract offers. Commonly, supply contracts become binding only when the first part has been delivered, long after sizable investments in development, capacity, and idiosyncratic tools have been made.

These prerequisites lead to a behavior that is similar to the one predicted in our model. Typically two distinct contractual models between the car manufacturer and the supplier can be observed. Either there are framework contracts over a car model lifetime with repeated price renegotiations or there are short-term contracts—much shorter than a car model lifetime—with the common pattern of multiple repeated transactions with the incumbent supplier. In both models, the procurer needs to decide on the level of information

[10] A case study survey by Florian Mueller, Konrad O. Stahl and Frank Wachtler, University of Mannheim, is forthcoming. The interview series received support from VDA, the Association of the German automotive industry.

he wants to have about his alternative option from the entrants before entering the renegotiations with the incumbent. Either he exercises pressure via auctions during the current contract lifetime, that give him the information about market prices, as well as an alternative option if the renegotiations don't succeed. Alternatively the procurer conducts internal re-engineering and production cost estimates, that supply him with the needed information before negotiating with his incumbent supplier. The procurer conducts a public auction only if the renegotiations fail. We identify these two basic strategies with the competitive mechanism, and the protective mechanism respectively, in the theoretical model. In fact, the resulting supply relationships (especially in the protective mechanism) to one incumbent are very long-lived and span at least one whole car model lifetime. One car manufacturer pointed out, that for the purchasing of some parts, he decided to switch to a model without frequent public auctions in order to reduce the number of supplier switches, without fearing to suffer from much higher purchasing prices, while applying internal information gathering about the purchased parts. This car producer was in fact even not a (pure) premium supplier and was thus operating in a strongly price driven market.

3.6 Extensions

In order to further approach a realistic behavior of the model, one can think of ample extensions.

One key feature of a model that emphasizes extensive treatment of infinite repetition would be to incorporate stronger interdependencies between the periods. One natural way to model this will be learning on the types of the other players or on the technology used. The first advocates the introduction of correlated types of the incumbent over time. It is less coercive to assume that the entrants' types should be correlated as well. In this setting the procurer will make his decision depend on the established type of the incumbent and will thus receive additional utility from a protective mechanism with potentially longer periods of business relations. Another way to extend the model in this direction is learning about the investment, which is closer related to the core of this model. One could for example think of an additional type variable of the suppliers, that governs the ability of the supplier to deliver the utility from the investment. This ability is correlated between the periods and should in a similar way lead to more favoritism for a strong incumbent and maintain the relationships between the two mechanisms. Learning by doing concerning the investment can also be analyzed in this spirit. This would lead to decreasing investment costs in consecutive periods in one business relation. The procurer would at the same time be better able to extract value from the incumbent due to the reduced investment cost, and we would see longer supply relations, due to the OEM's increased value from repeated transactions.

Our model so far demands commitment ability of the players only on behalf of the procurer, when deciding for one mechanism. One can also relieve this requirement, such that the mechanism decision takes place within each stage game on the verge of the first auction or offer. Thus the mechanism choice will now depend on the incumbent's chosen investment.

Our results can be augmented with the analysis of periods with variable length. The duration of a contract is now a property of the offer and the auction, which is set by the procurer upfront.

3.7 Conclusion

We have shown that, there exist situations in which one procurement mechanism dominates the other and vice versa. Moreover we could see, that in situations in which we have clearly higher direct market pressure with higher bids and with higher investment in the Competitive Mechanism, in a repeated game it pays for the procurer to 'protect' his incumbent, and by doing so, inducing a higher indirect market pressure. So the answer to the quest for the best mechanism needs to be: both, depending on the ability to realize benefits from cooperation and to extract the proceeds afterwards from the suppliers. This should be reflected in the procurement portfolio of firms, which exhibits many differences in the ability to produce benefits of cooperation, e.g., between standardized and new products, simple and sophisticated products, supply from countries with high or low cooperation potential. Furthermore, we suggest that in long-term contract models the pressure on the suppliers does not need to be lower, just because one observes obvious market interactions—like procurement auctions—less frequently.

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3.8 Appendix: Proofs equilibria

Proof of Proposition 1:

First we solve the incumbent's maximization problem:

Step C1: $d^* \in \max_{d\in\{0,1\}} \mathbf{E}[U_I|\theta_I]$ given $i, B_{E1}, \ldots, B_{En}, B_I$

$$\begin{aligned} d^*=1 &\implies -C(i)+\theta_I - B_I + \delta V_I \geq -C(i)+\delta V_E \\ &\implies \theta_I \geq B_I - \delta(V_I - V_E) = b_I \\ d^*=0 &\implies \theta_I \leq B_I - \delta(V_I - V_E) = b_I \end{aligned}$$

In equilibrium the probability of acceptance is uniquely given by

$$\text{Prob}(d^*=1) = 1 - F(b_I^*).$$

Given the acceptance decision of the incumbent, the procurer sets his offer B_I according to the following maximization problem:

Step C2: $B_I^* \in \max_{B_I\in\mathbf{R}} \mathbf{E}[U_P]$ given $i, B_{E1}, \ldots, B_{En}$

Now we determine the optimal offer to the incumbent b_I^*. If P wants I to accept the offer for sure, P will offer I the contract for the highest price I will always accept, i.e. $b_I = 0$. Conversely, offering $b_I \geq 1$ will always lead to a sure rejection, as this exceeds the maximum valuation. Therefore, we can restrict attention to $b_I \in [0,1]$.

Maximizing P's expected payoff by choosing $b_I \in [0,1]$ gives us

$$\begin{aligned} \max_{b_I\in[0,1]} \quad & \text{Prob}(d^*=1)(B_I + i + \delta V_P) + (1-\text{Prob}(d^*=1))(B_E + \delta V_P) \\ = \quad & F(b_I)(b_E - b_I - i) + b_I + i + \delta(V_P - V_I + V_E) \end{aligned}$$

The first derivative of the objective function is given by $f(b_I)(b_E - i - v(b_I))$ of b_I. Since $v(b_I)$ is strictly increasing by Assumption 1[11] and $f(b_I)$ is strictly positive, we get a corner solution $b^*=0$ if $b_E - i - v(0) = b_E - i + 1/f(0) \leq 0$ and a corner solution $b^* = 1$ if $b_E - i - v(1) = b_E - i - 1 \geq 0$. In all other cases we get the interior solution $b_I^* = v^{-1}(b_E - i)$. q.e.d.

Proof of Proposition 2:

[11] $v(x) := x - 1/h(x)$, $v'(x) = 1 + h'(x)/h(x)^2 > 0$ by Assumption 1.

The maximization problem for the entrants is:

$$\textbf{Step C3:} \quad B^*_{Ej} \;\in\; \max\nolimits_{B_{Ej}\in\mathbf{R}} \;\; \mathbf{E}[U_E|\theta_{Ej}] \quad \text{given } i$$

To obtain his optimal bidding function, entrant Ej solves for any of his types the following problem, given the optimal bidding function $b^*_{El}(\theta) = b^*(\theta)$ of all other entrants:

$$\begin{aligned} \max_{B_{Ej}\in\mathbf{R}} \quad & \text{Prob}(B^*_{El}(\theta_{El}) \leq B_{Ej}\ \forall l \neq j)\text{Prob}(d^* = 0)(\theta_{Ej} - B_{Ej} + \delta V_I) \\ + \quad & (1 - \text{Prob}(B^*_{El}(\theta_{El}) \leq B_{Ej}\ \forall l \neq j)\text{Prob}(d^* = 0))\delta V_E \end{aligned}$$

Equivalently:

$$\max_{b_{Ej}\in\mathbf{R}} \quad F(b^{*-1}(b_{Ej}))^{N-1}F(b^*_I(b_{Ej}))(\theta_{Ej} - b_{Ej}) + \delta V_E \tag{3.7}$$

In order to have a positive probability of winning, Ej must submit a bid such that P's offer to I is rejected with positive probability, i.e. $b_{Ej} > i - 1/f(0)$. Types $\theta_{Ej} \leq i - 1/f(0)$ are not willing to do so. For them any bid $b_{Ej} \leq \theta_{Ej}$ is optimal:

$$b^*(\theta) \leq \theta \text{ for } \theta \leq i - 1/f(0)$$

In the remainder of this proof we derive properties of $b^*(\theta)$ for $\theta > i-1/f(0)$.

Property 1: $b^*(\theta)$ is strictly increasing. Proof by contradiction. A direct consequence of this property is that $b^*(\theta)$ **is differentiable almost everywhere.**

Property 2: $b^*(\theta)$ is continuous. Proof by contradiction.

Property 3: $\lim_{\theta\downarrow\max\{0,i-1/f(0)\}} b^*(\theta) = \theta$**.** Proof by contradiction.

Property 1 and 3 imply that $b^*(\theta) > i-1/f(0)$ for all relevant types. Since Ej never bids more than his type—and thus never more than his maximum type 1. This implies $b^*(\theta) \leq i + 1$. Hence, we are always in the case of proposition 1 with $b^*_I = v^{-1}(b - i)$.

Using this, the objective function in problem (3.7) can be written as

$$U_{Ej}(b_{Ej}) = F(b^{-1}(b_{Ej}))^{N-1}F(v^{-1}(b_{Ej} - i))(\theta_{Ej} - b_{Ej}) + \delta V_E.$$

If $b^*(\theta_{Ej})$ is the maximizer of $U_{Ej}(b)$, the following must be true:

$$\begin{aligned} & U_{Ej}(b^*(\theta_{Ej}) + \epsilon) \leq U_{Ej}(b^*(\theta_{Ej})) \\ \iff \quad & \frac{U_{Ej}(b^*(\theta_{Ej}) + \epsilon) - U_{Ej}(b^*(\theta_{Ej}))}{\epsilon} \begin{cases} \leq 0 & \text{for } \epsilon > 0 \\ \geq 0 & \text{for } \epsilon < 0 \end{cases} \\ \implies \quad & \begin{cases} \lim_{\epsilon\downarrow 0} \frac{U_{Ej}(b^*(\theta_{Ej})+\epsilon)-U_{Ej}(b^*(\theta_{Ej}))}{\epsilon} \leq 0 \\ \lim_{\epsilon\uparrow 0} \frac{U_{Ej}(b^*(\theta_{Ej})+\epsilon)-U_{Ej}(b^*(\theta_{Ej}))}{\epsilon} \geq 0 \end{cases} \end{aligned}$$

For all $\theta_{Ej} \in (\max\{0, i-1/f(0)\}, 1)$ where $\dot{b}^*(\theta_{Ej})$ exists, both limits coincide and the expression on the left-hand-side must be zero. Reformulating this, we obtain (3.1). q.e.d.

Proof of Proposition 3:

The incumbent's maximization problem is given by:

$$\textbf{Step C4:} \quad i^* \quad \in \quad \max_{i \in \mathbf{R}_+} \quad \mathbf{E}[U_I]$$

We prove the proposition for three cases.

Case 1: For $i \in [0, 1/f(0)]$, we have $b_I^* = v^{-1}(b_E^*(\theta_E) - i) \in [0,1]$ and can apply the Revenue Equivalence Theorem (see Lemma 1 in Appendix 3.9) to obtain

$$\begin{aligned} R(i) &= \int_0^1 \int_{s^{-1}(\theta_E|i)}^1 (\theta_I - v(\theta_I)) dF(\theta_I) dF(\theta_E)^N \\ &= \int_0^1 \int_{s^{-1}(\theta_E|i)}^1 (1 - F(\theta_I)) d\theta_I dF(\theta_E)^N \\ R'(i) &= \int_0^1 -\frac{ds^{-1}(\theta_E|i)}{di} (1 - F(s^{-1}(\theta_E|i))) dF(\theta_E)^N \end{aligned}$$

To show that revenue is increasing it remains to show that $s^{-1}(\theta_I|i)$ is decreasing in i. This means that higher i shifts the separation function s to the left, such that the incumbent obtains the procurement contract more often. Since s^{-1} is implicitly defined by (3.2) holding with equality, i.e.

$$s^{-1} = v^{-1}(b^*(\theta_E) - i), \tag{3.8}$$

we have

$$\frac{ds^{-1}}{di} \quad = \quad \frac{\frac{db^*(\theta_E)}{di} - 1}{v'(v^{-1}(b^*(\theta_E) - i))}. \tag{3.9}$$

Using (3.8) and (3.9) we obtain

$$R'(i) \quad = \quad \int_0^1 \underbrace{\left(1 - \frac{db^*(\theta_E)}{di}\right)}_{>1} \frac{1 - F(v^{-1}(b^*(\theta_E) - i))}{v'(v^{-1}(b^*(\theta_E) - i))} dF(\theta_E)^N. \tag{3.10}$$

The conjecture implies that this expression is positive.

Case 2: For $i \in [1/f(0), 1 + \frac{1}{f(0)}]$ we have $b_I^* = 0$ for $\theta_E \leq s(0|i)$ and $b_I^* = v^{-1}(b^*(\theta_E) - i)$ for larger values of θ. Hence,

$$\begin{aligned}
R(i) &= \int_0^{s(0|i)} \int_0^1 \theta_I dF(\theta_I) dF(\theta_E)^N \\
&\quad + \int_{s(0|i)}^1 \int_{s^{-1}(\theta_E|i)}^1 (\theta_I - v(\theta_I)) dF(\theta_I) dF(\theta_E)^N \\
&= \int_0^{s(0|i)} \int_0^1 \theta_I f(\theta_I) d\theta_I dF(\theta_E)^N \\
&\quad + \int_{s(0|i)}^1 \int_{s^{-1}(\theta_E|i)}^1 (1 - F(\theta_I)) d\theta_I dF(\theta_E)^N \\
R'(i) &= \int_{s(0|i)}^1 -\frac{ds^{-1}(\theta_E|i)}{di} (1 - F(s^{-1}(\theta_E|i))) d\theta_I dF(\theta_E)^N
\end{aligned}$$

Using (3.8) and (3.9) we obtain

$$R'(i) = \int_{s(0|i)}^1 \left(1 - \frac{db^*(\theta_E)}{di}\right) \frac{1 - F(v^{-1}(b^*(\theta_E) - i))}{v'(v^{-1}(b^*(\theta_E) - i))} dF(\theta_E)^N \tag{3.11}$$

Again, The conjecture implies that this expression is positive.

Case 3: For $i > 1 + 1/f(0)$ the offer to the incumbent is always $b_I^* = 0$ and so revenue does not respond on changes in the investment i. q.e.d.

Proof of Proposition 4:

The entrants' maximization problem is given by:

$$\textbf{Step P1:} \quad B_{Ej}^* \in \max_{B_{Ej} \in \mathbf{R}} \mathbf{E}[U_E|\theta_{Ej}] \quad \text{given } i, B_I, d$$

Since this is a standard symmetric first price auction, refer to any standard auction textbook, e.g. Krishna (2003). The continuation values do not influence this result. q.e.d.

Proof of Proposition 5:

The incumbents acceptance decision and the procurer's offer to the incumbent are captured in the maximization problem:

$$\begin{array}{llll}
\textbf{Step P1:} & B_{Ej}^* \in \max_{B_{Ej} \in \mathbf{R}} & \mathbf{E}[U_E|\theta_{Ej}] & \text{given } i, B_I, d \\
\textbf{Step P2:} & d^* \in \max_{d \in \{0,1\}} & \mathbf{E}[U_I|\theta_I] & \text{given } i, B_I
\end{array}$$

(Step P2) Analogous to (Step C1) in the Proof for Proposition 1.

(Step P3) Analogous to (Step C2) in the Proof for Proposition 1 with the highest bid of the entrants b_E being replaced by the expectation of the highest bid $\mathbf{E}[b_E^*]$, as the auction has not yet taken place. Since we know that $\mathbf{E}[b_E^*] \leq 1$ from Proposition 4, we can—compared to CM—omit one case of b_I^* which never occurs.

q.e.d.

Proof of Proposition 6:

The incumbent's optimization problem for the investment is given by:

$$\textbf{Step P4:} \quad i^* \in \max_{i \in \mathbf{R}_+} \mathbf{E}[U_I]$$

For all $i > \mathbf{E}[b_E^*] + 1/f(0)$ we have $b_I^* = 0$. Hence, I's revenue is equal for all i above this bound.

If $i < \mathbf{E}[b_E^*] + 1/f(0)$, we have $b_I^* = v^{-1}(\mathbf{E}[b_E^*] - i) \in [0,1]$ and can apply the Revenue Equivalence Theorem (see Lemma 1 in Appendix 3.9) to obtain

$$\begin{aligned}
R(i) &= \int_{b_I^*}^{1} (\theta_I - v(\theta_I)) dF(\theta_I) + \delta V_E \\
&= \int_{v^{-1}(\mathbf{E}[b_E^*]-i)}^{1} (1 - F(\theta_I)) d\theta_I + \delta V_E \\
R'(i) &= \frac{1 - F(v^{-1}(\mathbf{E}[b_E^*] - i))}{v'(v^{-1}(\mathbf{E}[b_E^*] - i))} > 0 \\
R''(i) &= -\frac{1 - F(v^{-1}(\mathbf{E}[b_E^*] - i))}{v'(v^{-1}(\mathbf{E}[b_E^*] - i))^2} \left[\frac{v''(v^{-1}(\mathbf{E}[b_E^*] - i))}{v'(v^{-1}(\mathbf{E}[b_E^*] - i))} + h(v^{-1}(\mathbf{E}[b_E^*] - i)) \right]
\end{aligned}$$

$R(i)$ is concave if $v''(x)/v'(x) \geq -h(x)$. q.e.d.

3.9 Appendix: Auxiliary Results

Lemma 1: Let θ_E be the highest of the entrants' types, i.e. let θ_E be distributed according to $F(\theta_E)^N$. Let d^*, b_I^* and b^* be as specified in the equilibrium of either PM or CM. Then we obtain, using the Revenue Equivalence Theorem,

$$\mathbf{E}[\mathbf{I}_{d^*=1} b_I^*] = \mathbf{E}[\mathbf{I}_{d^*=1} v(\theta_I)] \text{ and } \mathbf{E}[\mathbf{I}_{d^*=0} b^*(\theta_E)] = \mathbf{E}[\mathbf{I}_{d^*=0} v(\theta_E)]$$

with $v(\theta) = \theta - \frac{1-F(\theta)}{f(\theta)}$ being the virtual valuation function. distributed according to $F(\theta)$.

Proof. Since the take-it-or-leave-it-offer and the auction between the entrants can be interpreted as a complicated auction between the entrants and the incumbent in which the entrants have first-price paying rules and the incumbent has 'some kind of second-price paying rule', we can compute expected payments using the Revenue Equivalence Theorem (see Mas-Colell, Whinston, and Green (1995) Proposition 23.D.3). To do so we need the allocation rule and the expected profit of players (incumbent and entrant) of type zero from the auction. The allocation rule is specified by $d^* = 1$ and the lowest type players obtain zero profit from the actual auction. A lowest type entrant never has a positive probability of winning, a lowest type incumbent may have a positive probability of winning, but has to pay his entire valuation in this case. q.e.d.

3.10 Appendix: Proofs comparison results

Proof of Proposition 7:

(i) From Proposition 2 and Proposition 4 it follows that the 'lowest' type in the θ-interval bids at least as high in CM as in PM.

(ii) Furthermore,

$$\dot{b}^{\mathrm{P}} \overset{\text{Prop. 4}}{=} (N-1)r(\theta)(\theta - b^{*\mathrm{P}})$$

and

$$\dot{b}^{\mathrm{C}} \overset{\text{Prop. 2}}{=} (N-1)r(\theta)(\theta - b^{*\mathrm{C}}) \underbrace{\frac{1}{1-(\theta - b^{*\mathrm{C}})\frac{r(v^{-1}(b^{*\mathrm{C}}-i^{\mathrm{C}}))}{v'(v^{-1}(b^{*\mathrm{C}}-i^{\mathrm{C}}))}}}_{>1 \text{ for all } i^{\mathrm{C}} \text{ since } r,v'>0}$$

almost everywhere. This implies that if $b^{*\mathrm{P}}$ and $b^{*\mathrm{C}}$ were equal for some θ, $b^{*\mathrm{C}}$ increases faster.

Therefore, (i) and (ii) imply that the $b^{*\mathrm{C}}$ lies always weakly above the $b^{*\mathrm{P}}$ function. q.e.d.

Proof of Proposition 8:

a) From Proposition 3 and Proposition 6 we know that marginal revenue of investment is positive in CM for $i < 1 + \frac{1}{f(0)}$ and in PM for $i < \mathbf{E}[b_E^{\mathrm{P}}] + \frac{1}{f(0)}$. Marginal revenue is zero if i lies above this bounds. If cost parameters c_1 and c_2 are sufficiently low, I has an incentive to invest until marginal revenue becomes zero.

b) We prove this Proposition in two steps:

   i) $i^{*\mathrm{C}} < i^{*\mathrm{P}}_{\max}$ implies $i^{*\mathrm{P}} \geq i^{*\mathrm{C}}$

   ii) $i^{*\mathrm{C}} \geq i^{*\mathrm{P}}_{\max}$ implies $i^{*\mathrm{P}} = i^{*\mathrm{P}}_{\max}$

   ad i) We first show that for all $i < \mathbf{E}[b_E^{\mathrm{P}}] + \frac{1}{f(0)}$ marginal revenue is larger in PM than in CM.

$$
\begin{aligned}
R^{\mathrm{P}\prime}(i) &= \frac{1 - F(v^{-1}(\mathbf{E}[b_E^{*\mathrm{P}}] - i))}{v'(v^{-1}(\mathbf{E}[b_E^{*\mathrm{P}}] - i))} \\
&= \int_0^1 \frac{1 - F(v^{-1}(\mathbf{E}[b_E^{*\mathrm{P}}] - i))}{v'(v^{-1}(\mathbf{E}[b_E^{*\mathrm{P}}] - i))} dF(\theta_E)^N \\
&\overset{\text{by (3.6)}}{\geq} \int_0^1 \frac{1 - F(v^{-1}(b^{*\mathrm{P}}(\theta_E) - i))}{v'(v^{-1}(b^{*\mathrm{P}}(\theta_E) - i))} dF(\theta_E)^N \\
&\overset{[*]}{\geq} \int_0^1 \frac{1 - F(v^{-1}(b^{*\mathrm{C}}(\theta_E) - i))}{v'(v^{-1}(b^{*\mathrm{C}}(\theta_E) - i))} dF(\theta_E)^N \\
&\overset{[**]}{\geq} \int_{\max\{s(0|i),0\}}^1 \left(1 - \frac{db^{*\mathrm{C}}(\theta_E)}{di}\right) \frac{1 - F(v^{-1}(b^{*\mathrm{C}}(\theta_E) - i))}{v'(v^{-1}(b^{*\mathrm{C}}(\theta_E) - i))} dF(\theta_E)^N \\
&= R^{\mathrm{C}\prime}(i)
\end{aligned}
$$

   [*] holds since $(1 - F(x))/v'(x)$ is decreasing by the assumption in (3.5) and bids are more competitive in CM than in PM by Proposition 7.

   [**] holds since $(1 - F(x))/v'(x)$ is positive and since $b^{*\mathrm{C}}/di \in (0, 1)$.

   Suppose now the contrary, that $i^{*\mathrm{P}} < i^{*\mathrm{C}}$. Then we have

$$
\begin{aligned}
\mathbf{E}[U^P(i^{*\mathrm{P}})] &= \mathbf{E}[U^P(0)] + \int_0^{i^{*\mathrm{P}}} (R^{\mathrm{P}\prime}(i) - C'(i))di \\
\mathbf{E}[U^C(i^{*\mathrm{C}})] &= \mathbf{E}[U^C(0)] + \int_0^{i^{*\mathrm{P}}} (R^{\mathrm{C}\prime}(i) - C'(i))di \\
&\quad + \int_{i^{*\mathrm{P}}}^{i^{*\mathrm{C}}} (R^{\mathrm{P}\prime}(i) - C'(i))di
\end{aligned}
$$

   Optimality of $i^{*\mathrm{C}}$ implies that the last integral is positive, otherwise I would have an incentive to lower his investment. But then, by

$R^{\mathrm{C}\prime}(i) \geq R^{\mathrm{P}\prime}(i)$, I could increase his payoff in PM by also investing $i^{*\mathrm{C}}$. Contradiction.

ad ii) Assume to the contrary that $i^{*\mathrm{P}} < i^{*\mathrm{P}}_{\max}$, but $i^{*\mathrm{C}} > i^{*\mathrm{P}}_{\max}$. We show that in this case $C'(i^{*\mathrm{C}}) > R^{*\mathrm{C}\prime}(i^{*\mathrm{C}})$ would hold, contradicting optimality of $i^{*\mathrm{C}}$.

$i^{*\mathrm{P}} < i^{*\mathrm{P}}_{\max}$ together with concavity of R^{P} and convexity of C imply $C'(i^{*\mathrm{P}}_{\max}) > R^{\mathrm{P}\prime}(i^{*\mathrm{P}}_{\max})$. For $i \geq i^{*\mathrm{P}}_{\max}$ we have $C'(i) \geq C'(i^{*\mathrm{P}}_{\max})$. Showing that $R^{\mathrm{P}\prime}(i^{*\mathrm{P}}_{\max}) \geq R^{\mathrm{C}\prime}(i)$ for $i \geq i^{*\mathrm{P}}_{\max}$ concludes the proof.

$$
\begin{aligned}
R^{\mathrm{P}\prime}(i^{*\mathrm{P}}_{\max}) &= \frac{1-F(v^{-1}(-1/f(0)))}{v'(v^{-1}(-1/f(0))} \\
&\overset{[***]}{\geq} \int_0^1 \left(1-\frac{db^{*\mathrm{C}}(\theta_E)}{di}\right)\frac{1-F(v^{-1}(-1/f(0)))}{v'(v^{-1}(-1/f(0))}dF(\theta_E)^N \\
&\overset{[****]}{\geq} \int_{s(0|i)}^1 \left(1-\frac{db^{*\mathrm{C}}(\theta_E)}{di}\right)\frac{1-F(v^{-1}(b^{*\mathrm{C}}(\theta_E)-i))}{v'(v^{-1}(b^{*\mathrm{C}}(\theta_E)-i))}dF(\theta_E)^N \\
&= R^{\mathrm{C}\prime}(i)
\end{aligned}
$$

[***] follows from $b^{*\mathrm{C}}/di \in (0,1)$.

[****] follows from $(1-F(x))/v'(x)$ being decreasing and $-1/f(0) \leq b^{*\mathrm{C}}(\theta_E) - i$ since $b^{*\mathrm{C}}(\theta_E) > i - 1/f(0)$ for $\theta_E > s(0|i)$ by Proposition 2.

q.e.d.

Proof of Proposition 9:

(I) If cost parameters are sufficiently close to zero, investment levels in CM and PM are arbitrarily close to $i^{*\mathrm{C}}_{\max}$ and $i^{*\mathrm{P}}_{\max}$, and I wins the contract in each period with a probability arbitrarily close to one. Furthermore, investment cost are negligible in this case. Plugging this in (3.4) and comparing obtains the result.

(II) Consider cost parameters such that $i^* := i^{*\mathrm{P}} = i^{*\mathrm{C}} = i^{*\mathrm{P}}_{\max}$. If $i^{*\mathrm{C}}$ behaves continuously for varying cost parameters, existence of such parameter constellations is guaranteed by Proposition 8. Plugging this investment in expression (3.4) we obtain

$$\text{for PM:} \quad -C(i^*) + \underbrace{\mathbf{E}[(\theta_I + i^*)]}_{[1P]} \underbrace{- \frac{N+1}{N}\mathbf{E}[0]}_{[2P]}$$

$$\text{for CM:} \quad -C(i^*) + \underbrace{\mathbf{E}[\mathbf{I}_{d^{*\mathrm{P}}=1}(\theta_I + i^*) + \mathbf{I}_{d^{*\mathrm{P}}=0}\theta_E]}_{[1C]}$$

$$\underbrace{- \frac{N+1}{N}\mathbf{E}[\mathbf{I}_{d^{*\mathrm{P}}=0}(\theta_E - b^*(\theta_E))]}_{[2C]}$$

If $i^* \geq 1$, which is particularly satisfied if there are sufficiently many entrants, such that $1/f(0) + \mathbf{E}[b^{*\mathrm{P}}_E] \geq 1$, we unambiguously have $[1P] > [1C]$ independently of how $\mathbf{I}_{d^{*\mathrm{C}}=1}$ exactly looks like. Furthermore we have $[2P] > [2C]$.

q.e.d.

4. “INEFFECTIVE” COMPETITION – A PUZZLE?

4.1 Introduction

Increased competition between firms in a market can be defined as an increase in the number of firms present or, alternatively, as a decreased horizontal differentiation between a constant number of firms in a fixed market. Standard thinking about these two kinds of competition in an oligopolistic market would suggest that an increase in competition may lead to weakly lower prices in this market.

In contrast, oligopoly models with additional features like repeated interactions, collusion, threats, or taste for variety, eventually produce a countervailing effect. But even these models in general display the conventional competition effect as described above. So will, for example, more competition in equilibrium also lead to a decreased propensity of collusion and thus lower prices.

We show in this contribution, that even in a simple setting of horizontally differentiated goods increased competition[1] may in fact lead to higher prices without explicit communication amongst the players.

We use a one stage standard model of horizontal differentiation as introduced by Hotelling (1929) and Salop (1979) to lay out the theoretical grounds. The existence of this effect has in principle been mentioned (in particular in Salop (1979) and Economides (1989)) before, but has never been appreciated as reasonable strategic behaviour of the players. However, we find empirical evidence, that this effect exists in reality.

We analyze the comparative statics of the model in depth in section 4.3. Subsequently in section 4.4, we find evidence for a positive relationship between prices and the density of firms in a market of petrol stations in German cities.

Our theoretical model closely follows the basic setup and equilibria of the pricing game as introduced by Salop (1979). Readers familiar with this work are welcome to skip section 4.3 completely, or go to sections 4.3.4 and 4.3.5 for a review of the best response strategies of the firms and the resulting equilibria before continuing with section 4.4.

4.2 Literature

To a large extent, the post-Hotelling (1929) literature on horizontally differentiated products concerned itself with finding the existence of an equilibrium in a Hotelling model of positioning and pricing, ever after d'Aspremont,

[1] Here, the two kinds of increased competition coincide in terms of optimizing behaviour of the firms.

Gabszewicz, and Thisse (1979) have shown that the original specification of Hotelling (1929) did note have a pure strategy Nash equilibrium in the pricing subgame for firm locations that were too close to each other. Also, for example, Anderson (1986; 1988) and Osborne and Pitchik (1987) investigate mostly the existence of equilibria. Those from this group that report the pricing behaviour as a function of distance all have a monotone positive relationship between the two.

On the other hand, Salop (1979) and Economides (1989) are two works that do report the non-monotone price behaviour that we investigate here, although these authors seem to have believed the effect to be strange and difficult to see in reality. These papers differ from the first group in one critical point: their models have an outside option for consumers to choose, while the former models forced all consumers to participate in the market. In our model—which is a direct descendant of Salop (1979)—if all consumers were made to buy at least from one firm, the pricing behaviour would also be monotone.

There exists other work that also derives seemingly counter-intuitive (at least from traditional point of view) results about the behaviour of the firms in horizontally differentiated marketplaces, but these papers have different settings. For example, Stahl (1982) and Schulz and Stahl (1996) study externalities from many firms in one marketplace, which may lead single-product firms in one marketplace to charge higher prices than a multi-product monopolist. They do not look at competing marketplaces, which makes their results different to our paper.

4.3 The Model

Our goal is to investigate the pricing of a duopoly in a differentiated goods market, where the degree of differentiation is given by a transportation cost à la Hotelling. As reference cases, we use the pricing strategies in two monopoly settings.

4.3.1 Set-up

The market is given by a Salop circle[2] of circumference $2 \cdot s$. Each point on the circle represents a differentiated good that is most preferred by a consumer occupying that point. Consumers are uniformly distributed along the circle, with density $1/s$, which results in a constant consumer mass of 2. There are two identical firms, positioned exactly opposite each other at 0 and s. Like

[2] cf. Salop (1979)

Salop (1979), we are interested in the analysis of the short term behaviour in the pricing game and thus we also assume that the firms' positions are fixed exogenously. We normalise marginal costs of production to zero. When a consumer x consumes a good offered at $y \neq x$, he incurs a disutility or transportation cost, $t \cdot |x - y|$, according to the shortest arc-length distance between x and y. Consumption of either good delivers to the consumer a pure utility of $a > 0$ in monetary terms, which is then adjusted for the price paid and the transportation cost.

Earlier work was concerned with the non-existence of pure strategy equilibria in similar Hotelling settings. We choose our set-up in a simple way, such that typical problems pertaining to pure strategies[3] do not occur, in order to allow for clear presentation of our case. This relates to the amount of firms and their symmetric position, given which, it is impossible to obtain the *hinterland* of your competitor. Take firm i, which prices such that the consumer at location of its rival, $-i$, just prefers $-i$ to i. Lowering its price by a small amount, firm i does not gain all of the consumers *on the other side* of $-i$, because it has already been serving those consumers from the other side of the circle. The *hinterland* does not exist.

Due to the same reasoning and for simplicity of exposition we can cut the circle in half and obtain our market as a line from 0 to s with firms positioned on the opposite sides and consumers uniformly distributed with density $1/s$ and a total mass of one.

4.3.2 Consumption decision

Consumers are utility maximizers and buy one or zero units of a good from at most one of the companies present. This decision is summarised in the conditions (4.1) and (4.2) below. If they buy zero units from the firms in question, they buy some homogeneous outside good, which costs 0 and delivers 0 utility to every consumer, irrespective of location.

Definition 1 (Utility form): Let $a, s, t \in \mathbb{R}_+$. For the person located at an address x between 0 and s (at a distance $z_0 = x$ or $z_1 = s - x$ from firm 0 or firm 1 respectively), when buying a good from firm i at price p_i, the indirect utility is given by the additive separable function

$$u_x(p_i, z_i) = a - p_i - t \cdot z_i \ .$$

[3] e.g., jumps in demand due to undercutting the rival's price, leading to non-existence of pure strategy equilibria.

Thus, given firms' prices $p_i, p_{-i} \in [0, a]$, the consumer located at x buys product i if and only if: (a) he prefers good i to good $-i$,

$$u_x(p_i, z_i) \geq u_x(p_{-i}, z_{-i}) \tag{4.1}$$

and (b) he prefers good i to the outside option,

$$u_x(p_i, z_i) \geq 0 \tag{4.2}$$

4.3.3 Aggregate demand and firms' profits

As the consumers do not act strategically, we can map their decisions directly into the (piece-wise linear) demand function for the firms. The firms can capture the market from their position up to an indifferent consumer. This consumer is either indifferent between buying the firm's product and buying the other product (fulfilling (4.1) with equality)or he is indifferent between buying the product and not buying (fulfilling (4.2) with equality). Consumers further away from the firm than the indifferent consumer either buy the other product or do not buy at all. There either exists one indifferent consumer, if all consumers are served or there are two indifferent consumers, if some consumers in the middle of the market are not served.

Firms set prices $p_i \in [0, a]$—a compact, convex set. Setting any price equal to or above a would lead to demand of zero for firm i. Therefore, we establish the upper bound a on the price set. Relaxing this assumption does not change the results.

The piece-wise demand equation for firm i is then given by the distance from that firm to the closest indifferent consumer weighted with the density of consumers $1/s$ on that part of the market.

(4.3)
$$D_i(p_i, p_{-i}|a, s, t) = \max\left\{\underbrace{0}_{[0]}, \min\left\{\underbrace{\frac{a - p_i}{st}}_{[1]}, \underbrace{\frac{1}{2} + \frac{1}{2st}(p_{-i} - p_i)}_{[2]}, \underbrace{1}_{[3]}\right\}\right\}$$

The piece-wise linear parts of the demand can be associated with regions of demand patterns, which are described below. An example for the demand for firm i's product depending on its price p_i is shown in figure 4.1.

[0] Demand is zero if a firm prices higher than the price of its competitor at the firm's location $\big((p_i \geq p_{-i} + st) \wedge (p_{-i} \leq a - st)\big)$ or too high for all consumers at $(p_i = a)$

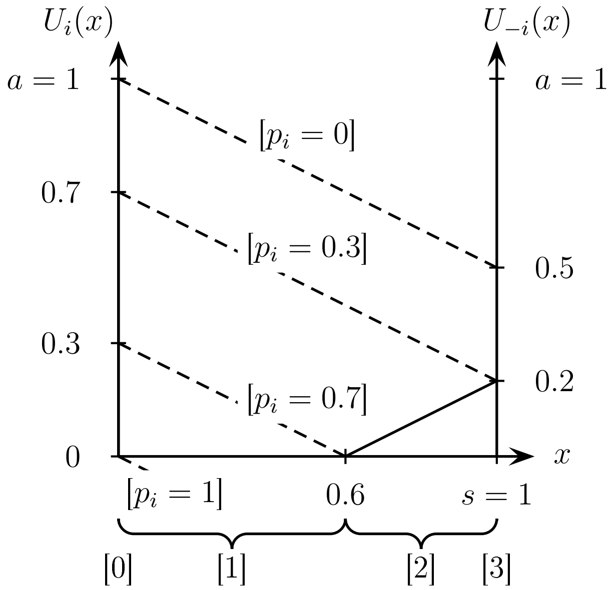


Fig. 4.1: Example consumer utility levels for different prices p_i with fixed parameters $p_{-i} = 0.8$, $a = 1$, $t = 0.5$ and $s = 1$

[1] The first interesting part of demand corresponds to firm i being a local monopolist. A small decrease in price leads to engaging previously idle consumers in trade; a small increase leads to him losing customers to the outside option.

[1]-[2] The kink between parts [1] and [2]. If the firm lowers its price, it steals the customers from the competitor; if it increases its price, some customers switch to the outside option—*not* to the competitor.

[2] This part corresponds to competitors being in “effective” competition: the market is covered, and any change in prices leads to stealing consumers from—or driving your consumers to—the competitor. This occurs for prices $p_i \in (p_{-i} - st, 2a - p_{-i} - st)$.

[3] This part corresponds to firm i capturing the whole market, which occurs at prices $p_i < p_{-i} - st$, or $p_i < a - st$ if firm $-i$ prices itself out of the market.

Of course, depending on the competitor's price p_{-i} and the parameters a, s, and t, some of these regions may not exist at all:

- If there is no competitor (or $p_{-i} > a$), then part [2] collapses.

- If $p_{-i} < a - st$ (low enough) and $st > a$, there is no part 1: even for very high p_i firm i would "effectively" compete with firm $-i$.

- If $p_{-i} < st$ or $st > a$, there is no (profitable) part 3: even for very small $p_i > 0$ firm i cannot capture the whole market from firm $-i$, either because firm $-i$ prices too low or the transport across the whole market is too expensive.

From the demand equation (4.3) we get the profit function by multiplying by the price p_i: $\Pi_i(p_i, p_{-i}|a, s, t) = p_i \cdot D_i(p_i, p_{-i}|a, s, t)$. We write out the profit function covering the full space of $p_{-i} \in [0, a]$ and the parameters a,s,t $\in \mathbb{R}_+$.

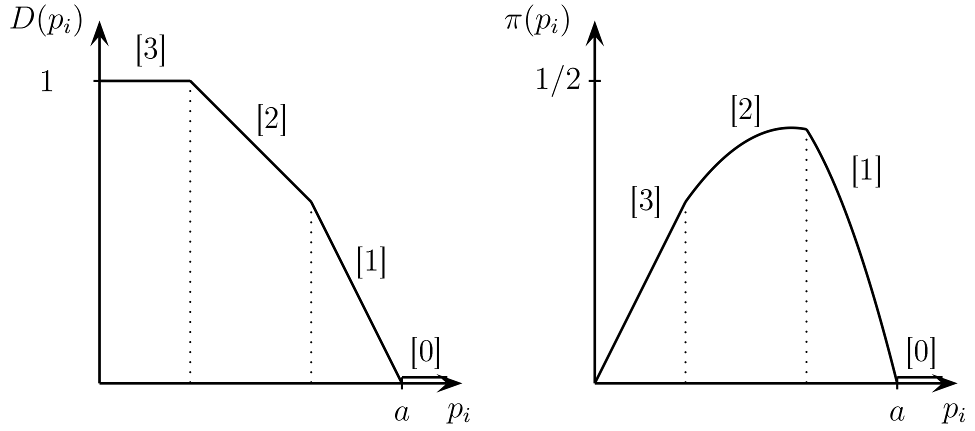
$$\Pi_i(p_i, p_{-i}|a, s, t) = \tag{4.4}$$

$$\begin{array}{l} [0] \\ \\ [1] \\ \\ [2] \\ \\ [3] \\ \\ \end{array} \begin{cases} 0 & \big((p_i \geq p_{-i} + st) \wedge (p_{-i} \leq a - st)\big) \\ & \vee (p_i \geq a) \\ \frac{a-p_i}{st} \cdot p_i & (2a - p_{-i} - st \leq p_i \leq a) \\ & \wedge (p_{-i} \geq a - st) \\ \left[\frac{1}{2} + \frac{1}{2st}(p_{-i} - p_i)\right] \cdot p_i & (p_{-i} - st \leq p_i \leq 2a - p_{-i} - st) \\ & \wedge (p_{-i} \leq a) \\ p_i & \big((p_i \leq p_{-i} - st) \wedge (p_{-i} \leq a)\big) \\ & \vee \big((p_i \leq a - st) \wedge (p_{-i} \geq a)\big) \end{cases}$$

Function $\Pi_i(p_i, p_{-i}|a, s, t)$ is quasi-concave and continuous in p_i. The positive part is strictly concave. Therefore, the function has a unique maximum above zero. In fact, given any quadruplet (p_{-i}, a, s, t), the maximiser lies either in the interior of one of the non-zero piece-wise components [1] or [2] of the profit function, or in one of the corners of part [2]. One example for the demand and profit function for a parameter set at which all regions exist is depicted in figure 4.2.

4.3.4 *Best responses*

Maximising the profit from equation (4.4) with respect to p_i, we get firm i's continuous best response function $p_i(p_{-i}|a, s, t)$. For discussion, we name the areas of the best response function. The pieces span the space for all



(a) Demand (b) Profit

Fig. 4.2: Demand and profit regions at fixed parameters p_{-i}, a, t, and s as in the example in figure 4.1

parameters as shown in figure 4.3.

$$p_i(p_{-i}|a, s, t) = \tag{4.5}$$
$$\begin{array}{r} \text{GM} \\ \text{CM} \\ \text{EC} \\ \text{IC} \\ \text{LM} \end{array} \begin{cases} a - st & (p_{-i} \geq a) \wedge (st \leq \frac{a}{2}) \\ p_{-i} - st & (p_{-i} \leq a) \wedge (p_{-i} \geq 3st) \\ \frac{st+p_{-i}}{2} & (p_{-i} \leq 3st) \wedge (p_{-i} \leq \frac{4}{3}a - st) \\ 2a - st - p_{-i} & (p_{-i} \leq \frac{3}{2}a - st) \wedge (p_{-i} \leq a) \wedge (p_{-i} \geq \frac{4}{3}a - st) \\ \frac{a}{2} & (st \geq \frac{a}{2}) \wedge (p_{-i} \geq \frac{3}{2}a - st) \end{cases}$$

The parameters for the market size s between the firms and for the relative transportation cost t always enter in the same way as a product for the total transportation cost across the whole market st, such that we don't need to treat them separately from now on. We discuss the firms' rationale behind this best response function by letting st increase and thereby taking us through the different regions of the best response function.

GM Global monopoly—occurs when the competing firm has totally priced itself out of the market ($p_{-i} \geq a$) and the total transportation cost is so low, such that the firm finds it optimal to set a price to just serve the whole market (region [3] of the demand and of the profit equation).

CM Capturing the whole market—also corresponds to part [3] of the demand function. Here the competitor is active in the market ($p_{-i} < a$), but charges too high a price ($p_{-i} \geq 3st$) such that firm i maximises profit in this region by charging the highest price that allows it to capture the whole market against the price of the competitor.

EC Effective competition—the best response refers to an inner maximum over the part [2] of demand and of profit equation. Here, the total transportation cost is low enough relative to the reservation utility, such that the firm engages in competition that serves every consumer at positive utility.

IC Ineffective competition—refers to the kink [1]-[2] in the demand function and in the profit function. The firm prices such that the indifferent consumer is just indifferent between buying from either firm or not buying at all. Note that the prices in this region are strategic substitutes: $\partial p_i(\cdot)/\partial p_{-i} < 0$.

LM Local monopoly—refers to inner maximum over part [1] of the demand and profit function. The total transportation cost here is high enough, such that the firm can ignore the presence of the competitor and set prices in a local monopoly. Consumers in the middle remain unserved.

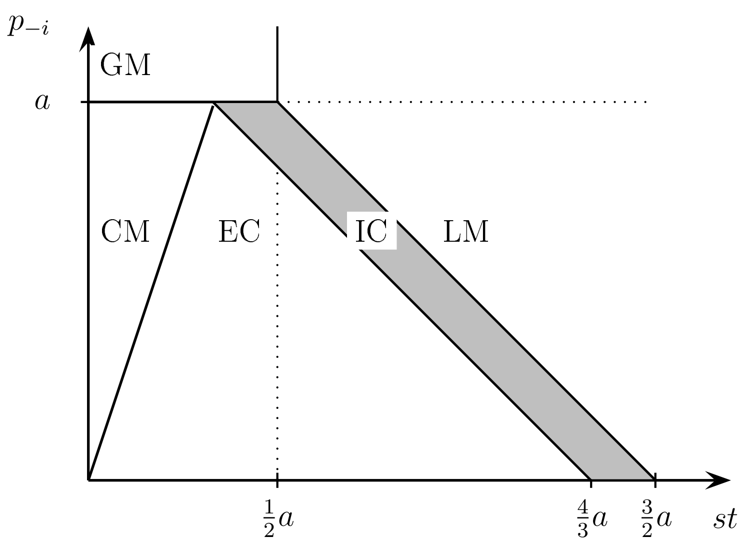


Fig. 4.3: Areas of the best response function p_i in p_{-i}–st space

4.3.5 Equilibrium

Solving the system of best response functions, we find that there is a unique pure strategy symmetric Nash equilibrium, with an equilibrium price p_i^* for any parameter tuple (a, s, t). We characterise our equilibrium in terms of st's relation to a as we are interested in the comparative statics with respect to the level of the exogenous parameters st.

$$p^* = \begin{cases} st & \text{if } st \leq \frac{2}{3}a \\ a - \frac{st}{2} & \text{if } \frac{2}{3}a < st \leq a \\ \frac{a}{2} & \text{if } st > a \end{cases} \tag{4.6}$$

These equilibrium prices lie in three different regions of the best response function (EC, IC, and LM)—corresponding to three different rationales for the behaviour of the firms—depending on the transportation cost and the distance between the firms, st. The equilibrium price of the duopoly case is pictured with a solid line in figure 4.4. As reference cases we use the pricing of the one-product monopolist (dotted line) and of a two-product monopolist (dashed line).[4] For small st, the firms engage in effective competition and their behaviour corresponds to standard understanding of lower prices at lower levels of transportation cost or distance. The limit (as $st \to 0$) of this case is marginal cost pricing in a Bertrand competition with a homogenous good. For very high st values, the firms maximize profits by acting as local monopolists and setting the monopoly price $a/2$.

In the middle region ($st \in [a/2, a]$)we see the price first overshoot the one-product monopoly price and then return to the one-product monopoly price with higher st.

For $st \in [\frac{2}{3}a, a]$, the equilibrium lies in the region of "ineffective" competition and the duopoly firms act as a two-product monopolist without explicit communication or coordination through repeated games. They are led solely by profit maximization through setting prices. Notably, at all of these st, the firms price such that the indifferent consumer is exactly indifferent between the two goods and the outside option. The firms decide not to engage in competition, instead they evade competition by jointly exploiting the consumers as long as all consumers participate.

4.3.6 Discussion

We argue, that this equilibrium behaviour reflects a reasonable strategy in practice. The rigidity of the partitioning of the market and the adjustment

[4] Please refer to Appendix 4.6 for the computation of the reference cases.

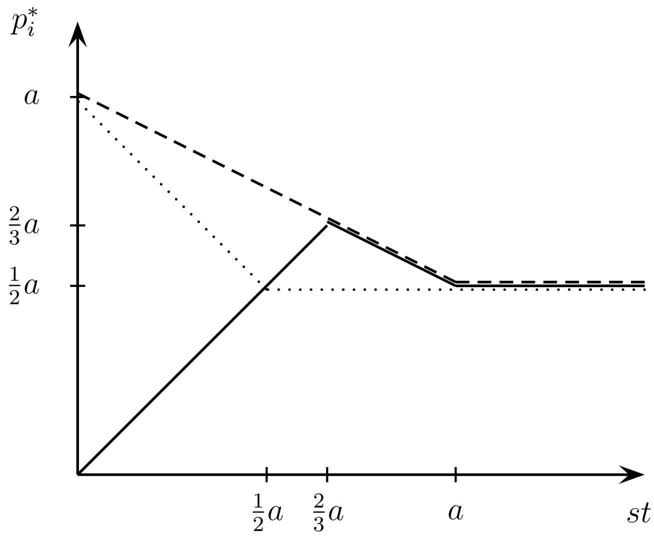


Fig. 4.4: Equilibrium prices in the duopoly, and the 1-product and 2-product monopoly reference cases

over prices is directly driven by the different price elasticities of demand for the firms. In this equilibrium, they face a discretely higher elasticity of demand for price increases than for price decreases because they lose more customers to the outside option when increasing the price, than they gain consumers from the competitor when lowering the price.

Similarly, we can assess the effects of ineffective competition in the comparison of the duopoly setting to the two-product monopoly setting. In the region of $st \in [\frac{2}{3}a, a]$, the firms in the duopoly set prices like a two-product monopolist, although they could engage in competition. Here, the market is in fact less than twice the size of the market a one-product monopolist would deliberately decide to serve at its profit-maximising price for the same set of parameters. However, the mere increase in the number of firms at the positions as described in the model on this specific st-range does not decrease the equilibrium prices. As compared to the one-product monopolist, we shall even see a price increase. This effect needs to be considered, when judging on firm concentration in such markets. The effect will be prevalent in markets that at the same time are horizontally differentiated, show limited market expansion as reaction to lower prices in the market, and have an outside option for the consumers.

4.4 Empirical model

In this section, we examine the prediction of our model that the relationship between the equilibrium market price and the distance between the firms is not monotonic across all distances—in particular, that it is not always positive. We do this by analysing the pricing behaviour of petrol stations along the station density in different city districts in Germany, where a district is an administrative unit at the level of a county ("Landkreis" or "Kreisfreie Stadt" in German), between a community and a state.[5]

We believe that this petrol market corresponds closely to the spatial competition as presented in our model, despite some problems discussed briefly below. We take the station density, denoted as ζ, as a proxy for the inverse of the distance between the firms ($1/s$) and we assume that the per distance transportation cost t is equal in all cities. Thus, we look at an equilibrium price in our model as a function of the station density ζ, together with the two kinks at ζ' and ζ'' as depicted in figure 4.5.

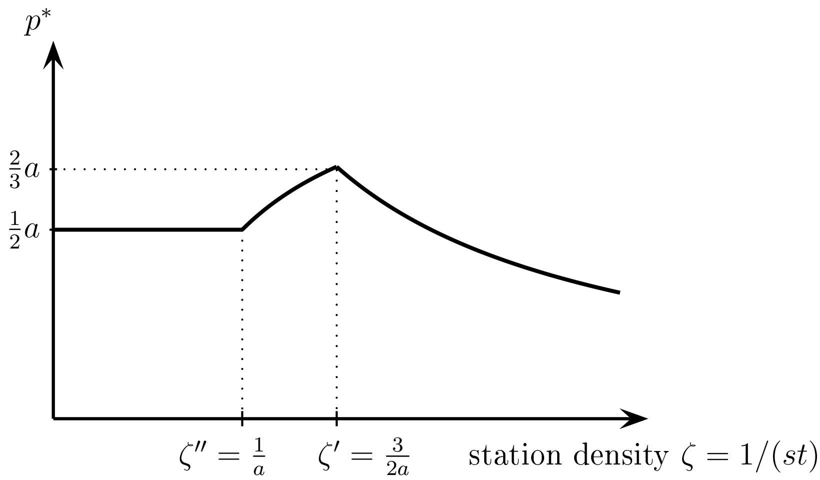


Fig. 4.5: Equilibrium price prediction for station density

It is clear that effective competition (to the right of ζ') is abundant, and this has in fact been shown in Karle (2005), for this particular data set. We do not believe that local monopolies exist in the market for petrol in German city districts, which is why we do not expect to find the part of the curve that is to the left of ζ'' in figure 4.5.

[5] City districts therefore contain a large city and its closest surroundings.

What we add to the discussion is the identification of the middle section of "ineffective competition": we first reject the hypothesis that the prices are a downward-sloping function of station density across *all* station densities, then we find a suitable value for a kink point ζ', and estimate a two-part connected linear curve around this kink.

To bridge the gap between the model of section 4.3 and our empirical work, we need to assume that consumers and stations are in fact distributed uniformly within the district, that consumers do frequent the closest station, *ceteris paribus*, and that districts have zero interaction with each other. Of course, these are strict assumptions. For one, consumers' locations are typically not given by their physical address, but rather by their every-day route to and from work (which furthermore may be in a different district). On the other hand, we believe that any distortion from these problems should enter in the same way irrespective of the observed station density. Therefore, these distortions should at worst hinder our analysis and at best have no effect, but they should not help us identify the upward-sloping part of the curve around the kink ζ' in figure 4.5.

4.4.1 Data

We use daily German petrol station price data collected for 78 days starting April 13, 2005, from a service website for retail petrol price comparisons.[6]

Some of the original sample entries had missing observations for our variables of interest. For example, Sunday and Saturday prices were largely not reported by the stations, so we only include weekday prices in the sample. While there were some observations from the rural districts, only the city districts ensure that the sample observations are representative of all the petrol stations in a district. At the end, we are left with a consistent sub-sample of the original data that contains daily price observations for 807 petrol stations in 93 major German city districts for 63 days.

The stations are divided into brand types: Premier-brand or A-type (e.g., Shell, BP), second-tier or B-type, and independent or C-type, according to their differentiation in the eyes of consumers.

We treat the districts as markets in the sense of section 4.3. Our dependent variable is the average retail price of one litre of petrol in a district, for each day and brand type, which gives us $14,984$ observations. We need to control for the changes in variables that may influence consumer preferences (the brand type, income) and marginal cost (local wholesale price per litre), as these are held constant in the model of section 4.3. In fact, the local

[6] For a detailed data description, see Karle (2005).

wholesale price changed dramatically during the sample period, while income is different across the districts. We thus consider as independent variables: station density in a district, income per capita in a district, the brand type and the local wholesale price.

The income is measured as local GDP per capita in a city; the local GDP is taken from “Volkswirtschaftliche Gesamtrechnungen der Länder 2003”. The wholesale price is the daily price reported for the petrol spot market in Rotterdam, by Energie-Informationsdienst; we take a 5-day moving average of this price to capture the adjustment lag of the retail price to the wholesale price changes. The local wholesale price is then the moving average of the Rotterdam price adjusted for time-persistent local differences, which are reported weekly by Europe Oil-telegram. The station density, ζ, is measured as the average number of stations per square kilometre in a district.

4.4.2 Testing for negative relationship between prices and station density

Suppose we know the value ζ' in figure 4.5. In order to test for negative price–station density relationship, we first partition the 14,984 observations into two parts according to the kink station density, $\bar{\zeta} = \zeta'$: with $n_1(\bar{\zeta})$ observations to the left of $\bar{\zeta}$, and $n_2(\bar{\zeta}) = 14,984 - n_1(\bar{\zeta})$ to the right. We then use OLS to estimate a two-part connected linear curve with a kink at $\bar{\zeta}$, which gives us two slope parameters for the curves on the right and left partitions. Last, we test the equality of these two parameters using a Chow test, which is stated formally below.

Of course, we cannot compute ζ'. Instead, we repeat our estimation and test pragmatically for different assumed values of $\bar{\zeta}$. We start with $\bar{\zeta} = 0.25$ and move down in increments of 0.005 until $\bar{\zeta} = 0.09$.

To estimate the two curves with the constraint that they meet at $\bar{\zeta}$, we transform the station density to be around 0 with:

$$\text{adjusted station density} = \text{station density} - \bar{\zeta}, \tag{4.7}$$

which permits us an estimation of one intercept for both parts of the curve in a single OLS regression. Now we can fit the two-part connected linear model, which allows for different parameters in different partitions:

$$\begin{bmatrix} p_1 \\ p_2 \end{bmatrix} = \begin{bmatrix} i & X_1 & 0 & Z_1 & 0 \\ i & 0 & X_2 & 0 & Z_2 \end{bmatrix} \cdot \begin{bmatrix} \alpha \\ \beta \\ \gamma \\ \delta_1 \\ \delta_2 \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \end{bmatrix}, \tag{4.8}$$

where p_1 and p_2 are the $n_1 \times 1$ and $n_2 \times 1$ vectors of the dependent variable observations (the average retail petrol prices in a district, for each day and brand type) in the left and right partitions, respectively; i is a vector of 1's; X_1 and X_2 are respectively $n_1 \times 1$ and $n_2 \times 1$ (left and right partition) matrices of station density observations; Z_j is an $n_j \times 4$ matrix of control variables for two partitions (with $j = 1, 2$ and the controls being: moving average of the Rotterdam wholesale price adjusted for local differences, income, and two dummies for brand types A and B); α is the price at the connection of the two lines (corresponds to the intercept since X_1 contains only negative values after the transformation); β and γ are the slope coefficients for the left and right partitions (X_1 and X_2, respectively); δ_j is the 4×1 vector of coefficients for Z_j, $j = 1, 2$; and $\epsilon_{1,2}$'s are the disturbances (assumed i.i.d.).[7]

We allow for different effects of the Z control variables in different partitions, by partitioning all the Z control variables according to the same kink station density $\bar{\zeta}$. Our hypothesised relationship between the station density and price is different for different partitions, but the model of section 4.3 is silent about the effects of independent variables other than station density. There is no reason to assume that the effect of, for example, marginal cost on price is the same in the ranges of effective and "ineffective" competition, since in the latter part the pricing is driven by the kink feature of the demand curve.

Given the empirical model in equation (4.8), our testable hypothesis is

$$\mathbf{H_0} : \beta = \gamma. \tag{4.9}$$

The data analysis shows that at any $\bar{\zeta}$, the right partition has a negative relationship between the price and station density. If the data can identify the part of the curve that is between ζ'' and ζ' in Figure 4.5, then our test will reject the equality of slopes for the right and left partitions around $\bar{\zeta} = \zeta'$. Furthermore, the slope of the left partition should be positive.

We assume that the disturbances have a zero mean and are uncorrelated with any of the regressors.

To cope with potential heteroscedasticity, we calculate the standard errors using the White covariance matrix, such that our estimation and tests are heteroscedasticity-robust.

4.4.3 Results

For all tested kinks points $\bar{\zeta} \leq 0.14$, we can reject the null hypothesis of equal slope coefficients in both partitions with at least 98% confidence. Fur-

[7] Our estimation and tests are robust to exclusion of the Z controls. We do not report the results here, but they can be obtained directly from the authors.

thermore, the slope in the left partition is positive and significant at a 1% level for all kink points $0.105 < \bar{\zeta} \leq 0.135$, and positive and significant at a 10% level for all kinks $\bar{\zeta} \leq 0.105$ and at a 5% level for $\bar{\zeta} = 0.14$. The model fits equally well for all the tested kink points (R^2 is slightly above 56%).

For large values of $\bar{\zeta}$, we cannot reject the null. Both slope coefficients are negative and significant and cannot be said to differ. The F-statistics and the associated p-values of the above tests for all $\bar{\zeta}$ are given in Table 4.2 in the appendix 4.7.

Thus, we have shown that the relationship between station density and prices is not monotonic. In particular, the relationship is positive for low station density, and becomes negative after a certain kink point. We conclude that this turning station density is around $\bar{\zeta} = 0.135$ (the highest tested potential kink point to deliver positive and significant slope of the left partition and still leave many observations to the left).

Finally, we fit the curve in equation (4.8) for $\bar{\zeta} = 0.135$. The results of the regression are given in table 4.1. To illustrate the relationship, we picture the fitted price curve against station density in figure 4.6.

Tab. 4.1: Estimation results of equation (4.8) with $\bar{\zeta} = 0.135$

Variable	**Coefficient**	**(Std. Err.)**
station density$\leq \bar{\zeta}$	0.102**	(0.012)
station density$> \bar{\zeta}$	-0.008**	(0.002)
marginal cost$_1$	0.965**	(0.008)
marginal cost$_2$	0.953**	(0.007)
income$_1$	0.000**	(0.000)
income$_2$	0.000**	(0.000)
A_1	0.020**	(0.001)
A_2	0.016**	(0.000)
B_1	0.013**	(0.001)
B_2	0.006**	(0.000)
Intercept	0.886**	(0.002)
N	14984	
R^2	0.566	
$F_{(10,14973)}$	2218.716	

Significance levels : † : 10% * : 5% ** : 1%

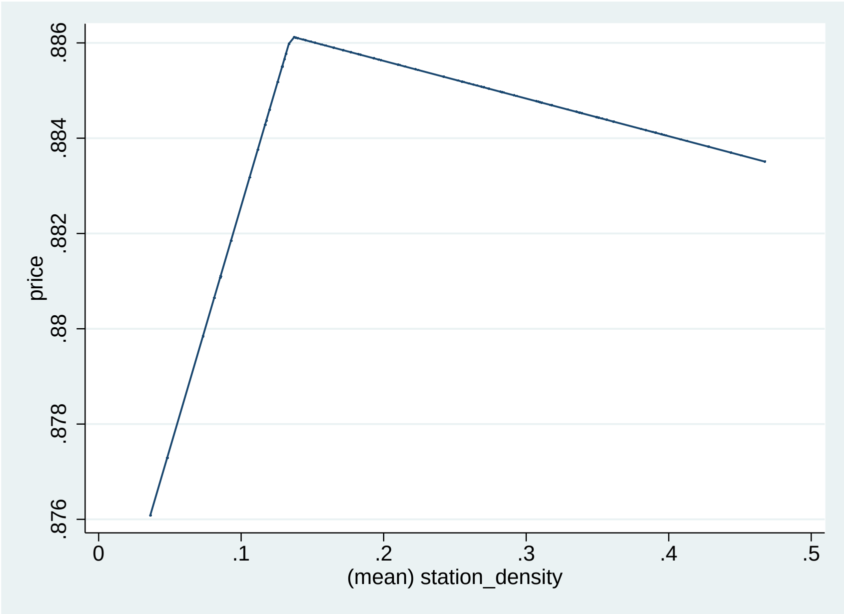


Fig. 4.6: Predicted prices

4.5 Conclusion

In this contribution we showed that increased competition may lead to higher prices in a simple model of horizontal differentiation. We especially analysed the comparative statics of this effect and we argued that it represents a rationalisable strategy of firms. Furthermore, we showed its existence in the retail gasoline market in Germany.

The set of markets in which this effect surfaces is, as usual, limited but exists, as we have shown in the empirical section. The market needs to be horizontally differentiated, it needs to have an outside option for all potential buyers, and its expansion due to lower prices needs to be limited. A strictly kinked demand curve, as in our simple example, is in fact not a necessary prerequisite, as one can show for a family of locally smoothed-out demand curves. Clearly also this model is only powerful with restricted entry and exit to the market, as we have for example in the short term examination that is done in the empirical part of the paper.

The model is general enough in its description of consumers and producers that it can also be applied to increased integration of international producer-supplier markets, which occurs when improved communication technologies and opening of the local markets reduce the perceived transportation costs[8] between previously distant agents. Take the product to be an intermediate input, the two producers to be the suppliers of this input, and the consumers as the manufacturers of a final good. As long as this producer-supplier market fulfils the conditions described in the previous paragraph, one of the model's predictions is that for a certain exogenous fall in the perceived transportation costs (i.e., more world integration) the manufacturers experience higher costs of intermediate inputs in the short run.

From a competition policy point of view, for the relevant markets with features as above, competition authorities need to consider this behaviour when judging on market concentration as classical concentration measures might be misleading, if they purely measure market share ratios of the participating firms.

Furthermore, the firms' strategy of 'evading competition' and accommodating to a shared market even without explicit communication needs to be appreciated as a reasonable and profit maximizing strategy of players in markets, that seemed to follow standard intuition of competition.

[8] These can include real transportation costs plus information costs, etc.

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4.6 Appendix: Reference cases

We compare the equilibrium price of our duopoly game to two reference cases: A one-product monopoly and a two-product monopoly.

4.6.1 One-product monopoly

One way to look at one-product monopoly is to fix the price of firm $-i$ in the duopoly profit equation (4.4) so as to price it out of the market: $p_{-i} = \hat{p}_{-i} > a$. Then, the regions [0] and [2] will disappear from the demand function (for prices $0 < p_i < a$), and we are left with

$$\Pi_i^M(p_i|a,s,t) = \begin{matrix} [1] \\ [3] \end{matrix} \begin{cases} \frac{a-p_i}{st} \cdot p_i & p_i > a - st \\ p_i & p_i \leq a - st \end{cases} \tag{4.10}$$

Solving the maximisation problem for the monopoly, we get the equilibrium prices as

$$p^{M*} = \begin{cases} a - st & \text{if } st \leq \frac{a}{2} \\ \frac{a}{2} & \text{if } \frac{a}{2} < st \end{cases} \tag{4.11}$$

4.6.2 Two-product monopoly

The two-product monopoly can be computed in the same framework, as one firm setting prices p_i and p_{-i} simultaneously. The firm will use symmetric prices as, without fixed cost for the second product, it is always better to supply the upper half of the market line with the product located at the upper end than to supply it from the lower end of the market and vice versa. This leaves more utility with the consumers, which can be extracted through higher prices. Thus we get the symmetric prices $p_i = p_{-i}$ and the profit is given by

$$\Pi_i^{2M}(p_i|a,s,t) = \begin{matrix} [1] \\ [3] \end{matrix} \begin{cases} \frac{a-p_i}{st} \cdot 2 \cdot p_i & p_i > a - \frac{st}{2} \\ p_i & p_i \leq a - \frac{st}{2} \end{cases} \tag{4.12}$$

Solving for the equilibrium prices yields

$$p^{*2M} = \begin{cases} a - \frac{st}{2} & \text{if } st < a \\ \frac{a}{2} & \text{if } a \leq st \end{cases} \tag{4.13}$$

4.7 Appendix: Chow Test results

Tab. 4.2: The F-statistic and the associated p-values for the Chow test for the parameter stability at different $\bar{\zeta}$'s

increment	F	p	R^2
.25	2.218132	.136419	.5654151
.245	2.094088	.1478908	.5654117
.24	2.280698	.131014	.564586
.235	2.1578	.1418687	.5645825
.23	2.038049	.1534272	.564579
.225	1.921477	.1657146	.5645757
.22	2.729819	.0985114	.5672181
.215	2.879594	.0897294	.5672224
.21	2.79763	.0944247	.5656854
.205	1.596892	.2063639	.5622169
.2	1.499953	.2206978	.5622142
.195	.1695287	.6805369	.56202
.19	.0887485	.7657784	.5620067
.185	.0685921	.7934014	.5620061
.18	1.978202	.1596008	.5626864
.175	2.476331	.1155927	.5624058
.17	2.615331	.1058565	.562429
.165	2.786674	.0950722	.5624336
.16	3.745212	.0529778	.5608998
.155	2.042018	.1530274	.5609509
.15	5.64495	.0175182	.5626013
.145	2.282735	.1308421	.5620812
.14	9.525839	.0020297	.5621582
.135	79.31693	5.89e-19	.5661687
.13	82.42374	1.23e-19	.5652712
.125	53.00962	3.48e-13	.5628271
.12	52.13296	5.44e-13	.5628073
.115	40.56149	1.96e-10	.5638012
.11	12.34939	.0004424	.5638718
.105	6.764859	.0093062	.563678
.1	6.484803	.01089	.5636718
.095	6.206994	.0127354	.5636657
.09	15.73746	.0000731	.5644021

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