Essays in Industrial Organization: Vertical Agreements in a Dynamic View

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Zusammenfassung

Die vorliegende Dissertation beschäftigt sich mit vertraglichen Vereinbarungen von Unternehmen, welche auf unterschiedlichen Stufen der Wertschöpfungskette agieren. Insbesondere analysiert diese Arbeit die Besonderheiten der Vertragswahl als auch deren Konsequenzen, die im dynamischen Kontext mit intertemporalen Externalitäten entstehen können.

In der Einleitung wird eine gemeinsame Motivation der darauf folgenden Aufsätze dargelegt. Wettbewerbspolitische Entscheidungen über die Anwendung von vertikalen Verträgen als auch die Beachtung einer dynamischen Sichtweise verdeutlichen die Thematik, welche in den drei folgenden Aufsätzen näher behandelt wird.

Der erste Aufsatz analysiert die Vertragswahl eines dominanten Herstellers, welcher durch Lerneffekte seines Rivalen einem stärkeren Wettbewerb ausgesetzt wird. Als Lerneffekt wird hierbei die Tatsache bezeichnet, dass abhängig von den bereits verkauften Einheiten eines Produktes die Grenzkosten des Herstellers sinken. Der dominante Hersteller kann dem Einfluss dieser intertemporalen Externalitäten entgehen, indem er seine Preisstrategie anpasst. Marktanteilsverträge, welche den zu kaufenden Anteil der Gesamtnachfrage eines Käufers festlegen, haben gegenüber zwei-stufigen Tarifen oder Mengen-bezogenen Verträgen den Vorteil, dass sie den Gewinn des dominanten Herstellers optimieren. Diese Verträge führen dazu, dass die Lerneffekte des Rivalen geringer ausfallen als im Fall anderer Vertragsarten. Mithilfe einer Spezifikation der Nachfragefunktionen kann ferner nachgewiesen werden, dass die Verwendung von Marktanteilsverträgen des dominanten Herstellers im Vergleich zu den anderen Vertragsarten die Konsumentenrente als auch die Wohlfahrt mindert.

Während im ersten Aufsatz davon ausgegangen wird, dass es sich bei dem Rivalen um ein 'competitive fringe' handelt, d.h. im Kontext ein Unternehmen, welches nicht strategisch handeln kann, wird diese Annahme in den folgenden zwei Aufsätzen

angepasst.

Der zweite Aufsatz thematisiert bilaterale, sequentielle Verhandlungen zweier strategischer Hersteller mit einem Händler. Es kann gezeigt werden, dass in einem ein-periodigen Modell bereits Vertragsmenüs zwei-stufiger Tarife zum Industriegewinn-maximierenden Ergebnis führen. Somit ist eine zusätzliche Vertragsspezifikation im ein-periodigen Modell hinfällig. In einem zwei-periodigen Modell mit intertemporalen Externalitäten können zwei-stufige Tarife dieses Ergebnis jedoch nicht erzielen. Es wird gezeigt, dass der erste verhandelnde Hersteller, abhängig von den Modellannahmen, Marktanteilsverträge präferiert, da diese ausreichend viele Vertragselemente festlegen können um das kollusive Ergebnis zu erzielen. Die Vertragswahl des strategischen zweiten Herstellers hat indes keinen Einfluss auf das Ergebnis. Unter der Annahme, dass beide Hersteller durch Lerneffekte profitieren können, ergibt sich, dass ein Marktanteilsvertrag des ersten Herstellers die Lerneffekte des Rivalen einschränken oder beschleunigen kann, abhängig von der Verhandlungsposition der Hersteller gegenüber dem Händler. In gleicher Weise werden Konsumentenrente und Wohlfahrt durch Marktanteilsverträge des dominanten Herstellers entweder gemindert oder gestärkt.

Der dritte Aufsatz setzt sich mit der Vertragswahl von zwei simultan handelnden, strategischen Herstellern auseinander. Unter der Annahme vollständiger Information wird im ein-periodigen Modell gezeigt, dass das Industriegewinn-maximierende Ergebnis bereits mit Hilfe von zwei-stufigen Tarifen erreicht wird. Somit ist in einem statischen Rahmen die Verwendung von zusätzlichen Vertragsbedingungen unnötig. Im dynamischen Rahmen mit intertemporalen Externalitäten ergibt sich hingegen niemals das kollusive Ergebnis. Das Verhandeln von Marktanteilsverträgen oder aber Mengen-bezogenen Verträgen kann eine dominante Strategie für die Hersteller darstellen. Im Vergleich zu zwei-stufigen Tarifen nimmt der Wettbewerb abhängig davon, ob ein oder beide Hersteller Vertragsspezifizierungen vornehmen können, eine Stackelberg-ähnliche oder eine oligopolistische Form an. Vertragsspezifizierungen führen zu Gewinnsteigerungen, aber auch zu einer Wohlfahrtsverringerung.

Im letzten Kapitel wird ein Überblick über die wichtigsten Ergebnisse der Aufsätze gegeben. Der Zusammenhang dieser Erkenntnisse wird abschließend verdeutlicht.

Summary

This dissertation deals with the contract choice of upstream suppliers as well as the consequences on competition and efficiency in a dynamic setting with inter-temporal externalities.

The introduction explains the motivation of the analysis and the comparison of different contract types, as for example standard contracts like simple two-part tariffs and additional specifications as contracts referencing the quantity of the contract-offering firm or the relative purchase level. The features of specific market structures should be considered in the analysis of specific vertical agreements and their policy implications. In particular, the role of dynamic changes regarding demand and cost parameters may have an influence on the results observed.

In the first model, a dominant upstream supplier and a non-strategic rival sell their products to a single downstream firm. The rival supplier faces learning effects which decrease the rival's costs with respect to its previous sales. Therefore, learning effects represent a dynamic competitive threat to the dominant supplier. In this setup, the dominant supplier can react on inter-temporal externalities by specifying its contract to the downstream firm. The model shows that by offering market-share discounts, instead of simple two-part tariffs or quantity discounts, the dominant supplier maximizes long-run profits, and restricts the efficiency gains of its rival. If demand is linear, the market-share discount lowers consumer surplus and welfare.

The second model analyzes the strategic use of bilateral contracts in a sequential bargaining game. A dominant upstream supplier and its rival sequentially negotiate with a single downstream firm. The contract choice of the dominant supplier as well as the rival supplier's reaction are investigated. In a single-period sequential contracting game, menus of simple two-part tariffs achieve the industry profit maximizing outcome. In a dynamic setting where the suppliers sequentially negotiate in each period, the dominant supplier uses additional contractual terms that condition on the rival's quantity. Due to the first-mover advantage of the first supplier, the rival supplier is restricted in its contract choice. The consequences of the dominant supplier's contract choice depend on bargaining power. In particular, market-share contracts can be efficiency enhancing and welfare-improving whenever the second supplier has a relatively high bargaining position vis-à-vis the downstream firm. For a relatively low bargaining position of the rival supplier, the result is similar to the one determined in the first model. We show that results depend on the considered negotiating structure.

The third model studies the contract choice of two upstream competitors that simultaneously deal with a common buyer. In a complete information setting where both suppliers get to know whether further negotiations fail or succeed, a single-period model solves for the industry-profit maximizing outcome as long as contractual terms define at least a wholesale price and a fixed fee. In contrast, this collusive outcome cannot be achieved in a two-period model with inter-temporal externalities. We characterize the possible market scenarios, their outcomes and consequences on competition and efficiency. Our results demonstrate that in case a rival supplier is restricted in its contract choice, the contract specification of a dominant supplier can partially exclude the competitor. Whenever equally efficient suppliers can both strategically choose contract specifications, the rivals defend their market shares by adapting appropriate contractual conditions.

The final chapter provides an overview of the main findings and presents some concluding remarks.

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Chapter 1

Introduction

A vertical arrangement can be defined as *"an agreement [...] entered into between two or more undertakings each of which operates, for the purposes of the agreement [...], at a different level of the production or distribution chain"*.[1]

Based on standard contractual terms such as wholesale prices and fixed fees, a variety of contractual conditions exists that are used in negotiations between upstream and downstream firms.[2] From the firms' point of view it is questionable under which market conditions specific contract types can increase a firm's value. From a social point of view, it is rather questionable which consequences strategies of firms may have on market structure, competition and on consumer surplus and social welfare. The multi-faceted effects of contractual contents are extensively analyzed in the legal as well as economic literature.

Exclusive dealing agreements are one example of vertical contracts that give rise to competition concerns.[3] In these agreements, the firm offering the contract combines payment conditions with the fact that buyers, who accept the contract, are not allowed to purchase from other suppliers. Exclusive dealing could lead to

[1]Guidelines on Vertical Restraints, Official Journal of the European Union (2010/C 130/01), paragraph 24.

[2]Evidence can be found in legal decisions. In the *Michelin (II)* decision, retroactive rebates were used, see Manufacture francaise des pneumatiques *Michelin* v. Commission , 2003, Case T-203/01. In the *Intel* decision, it is shown that, among other things, market-share contracts were used, see *Intel* v. Commission Decision, 2009, Case COMP/C-3/37.990. In *Leegin*, the focus was set on resale price maintenance, see *Leegin* Creative Leather Products, Inc. v. PSKS, Inc., 551 U.S., 2007, to name only a few.

[3]For a first overview of the legal arguments on exclusive dealing contracts, see the Guidelines on Vertical Restraints (2010).

market foreclosure of potentially more efficient competitors (Aghion & Bolton, 1987; Rasmusen, Ramseyer, & Wiley, 1991; Segal & Whinston, 2000). In contrast, they could also enhance economic efficiency.[4]

A recent discussion addresses further contract types that give rise to similar competition concerns. Together with exclusive dealing agreements, these contract types are categorized as contracts that reference rivals (CRRs).[5] In accordance with Scott-Morton (2012), CRRs include market-share discounts which specify lower prices for buyers that purchase at least a specific share (x%) of the contract offering supplier (and at most (1-x)% from rival suppliers). A further example of quantity-related CRRs is an arrangement with volume discounts. In these contracts, the buyer and seller agree upon a standard price and discounts conditioned on specific purchase levels. Quantity discounts do not represent classic CRRs, but *"the particular thresholds at which discounts kick in may also mimic market-share discounts, and thus make the contract similar to a CRR"*.[6]

The reported discount schemes are dealt with in US antitrust cases as well as in European cases. Especially if dominant firms establish discount conditions these might have rather anticompetitive than procompetitive reasons. The jurisdiction however varies across countries, but also across cases. Due to the latter disparity, numerous lawyers besides economists criticize the non-uniform analysis of specific CRRs which makes it not clear for firms whether the use of such pricing strategies may be fined (Waelbroeck, 2005; Geradin, 2009; Faella, 2008; Bona, 2010). In particular, while in the United States of America (US), cases are often analyzed either by the rule of reason or as predatory pricing, in the European Union (EU) the courts apply the "as efficient competitor test" in cases of allegedly anticompetitive price-based conduct according to the more economic approach.[7] However, there are

[4]They could, for example, lead to larger non-contractible relation-specific investments of upstream and downstream firms (Whinston, 2008).

[5]Cf. Scott-Morton (2012), p. 4: CRRs are vertical agreements that refer to *"information outside the buyer-seller relationship: information from other transactions to which those same firms are party. There references may be either explicit or implicit, and they can involve a host of factors, including price terms, non-price terms, terms pertaining to the buyer's rivals, or terms pertaining to the seller's rivals"*.

[6]Cf. Scott-Morton (2012), p. 4. Price-based CRRs are inter alia most-favored nation clauses or, in the broadest sense, price relationship agreements (Aguzzoni et al., 2012).

[7]See section 1.1.

exceptions where predatory effects of CRRs are highlighted, without a more detailed economic analysis. Among others, Geradin, Ahlborn, Denicolo, and Padilla (2006) and Geradin (2015) criticize the courts' proceeding that, as they claim, does not suitably apply a more economic approach.

In this context, Geradin (2015) argues that the General Court of the European Union *"seems to have a 'static' view of dominance that is not a true reflection of many industries"*. The Court does not regard dynamic effects even though a more dynamic view is set down in the Guidance Paper (2009), paragraph 24. Especially in research-intensive markets, a dynamic view seems to be more appropriate. This position is supported by Carlton, Greenlee, and Waldman (2008), Scott-Morton (2012) and Fumagalli and Motta (2015)[8] and based on recent economic articles, for example Fumagalli and Motta (2014). The model shows that dynamic considerations about entry in upstream markets as well as entry in downstream markets have an influence on the outcome.[9]

Furthermore, dynamic markets are characterized by inter-temporal externalities such as learning-by-doing. Due to these cost reductions that depend on previous sales levels, the pricing strategy of firms can be influenced. If a supplier that faces learning-by-doing lowers its price in the present period, the price reduction can increase the supplier's efficiency gains in future. That is, below-cost pricing could be used due to further reasons besides exclusion. However, the impact of learning-by-doing in vertical supply chains is not extensively documented in the economic literature.[10]

[8] They note that *"whereas the US Appeals Court (3rd Circuit) judges apply a rule of reason where economic analysis and effects-based considerations play a crucial role, the EU General Court judges apply a very formalistic approach where the mere finding that a dominant firm uses a market-share discount (called 'exclusivity rebate') is sufficient to determine that it has abused of a dominant position"*.

[9] Dynamic games and multi-period models are common in the economic literature to investigate the impact of specific pricing strategies as for example exclusive dealing contracts (or to study settings with innovations). The mentioned models differ from the exclusive dealing literature in such a way that potential entry can occur in more periods, either in the upstream or in the downstream sector.

[10] An overview of the manifold literature on learning effects in horizontal markets can be found in section 1.2. To the best of our knowledge, there is only a single article, Kourandi and Vettas (2011), that deals with learning effects and exclusive dealing contracts, see section 1.2.

The thesis at hand contributes to this literature by analyzing three different models in which (active) upstream firms face inter-temporal externalities, in particular learning-by-doing. The firms can choose different kinds of CRRs to influence their own efficiency gains as well as their rivals'. The aim of this thesis is to gain proper insights about the impact of inter-temporal externalities on the pricing strategy of competing firms as well as the related consequences.

1.1 Selected decisions considering anticompetitive conduct in vertical structures

The legal treatment of exclusive dealing contracts and loyalty discounts varies across countries.

In the US, for example, the potential beneficial reasons of CRRs, especially for consumers, are on the focus. In cases with exclusive dealing agreements, US courts apply a rule of reason (FTC, 2015). In particular, the rule of reason compares the procompetitive and anticompetitive effects. Only if the anticompetitive effects predominate, exclusive dealing contracts are said to be illegally applied. In this case, these practices are prohibited according to the Sherman Act or the Clayton Act. Cases of loyalty discounts are either analyzed by the rule of reason or similar to cases of predatory pricing, with a price-cost-test (Geradin, 2015).

In the EU, the as efficient competitor test is applied in cases with exclusive dealing contracts and conditional discounts, according to a more economic approach. The test is a cost-benchmark-test used to determine whether a hypothetical (reasonably) equally efficient competitor is excluded from the market due to the pricing strategy of a dominant firm (EE&MC, 2015). The use of the as efficient competitor test in cases of price-based conduct, as for example the agreement on rebates, is recommended in the Guidance Paper (2009). According to the more economic approach that is emphasized in the Guidance Paper, the protection of consumers is on focus, not the protection of (potentially inefficient) competition.

To highlight the varying legal assessment in cases of CRRs as well as the characteristics of markets in which these contracts are inter alia used, we summarize the basic facts of some, selected decisions.

Eaton

One of the most recent decisions on market-share discounts is Eaton (2012).[11] Following the decision of the 3rd Circuit US District Court, Eaton was judged due to the market foreclosing effects of its long-term contracts and market-share discounts.

Since 1950, Eaton was the single manufacturer of heavy duty truck transmissions in North America. In 1989, Meritor entered the market as the only competitor of Eaton. After a merger with the German manufacturer ZF Friedrichshafen, ZF Meritor introduced a new product into the American market in 2001. It was the first two-pedal automated mechanical transmission sold in the American market. At the same time, Eaton entered into long term contracts with all four manufacturers of heavy-duty trucks and offered market-share discounts, conditioning on 68%, or more, of relative purchases (see for example section C. and D. of the Decision).

In the decision, the Court assessed the rule of reason instead of applying a price-cost test and found that the long-term agreements of Eaton at least partially excluded ZF Meritor. Therefore the long-term agreements were able to partially foreclose equally efficient rivals and harmed competition, irrespective of below-cost prices. ZF Meritor entirely left the American market in 2006.

Brunswick

In Brunswick (2002)[12], the dominant supplier for stern drive engines Brunswick was accused to use exclusionary discounts.

Brunswick introduced volume discounts as well as market-share discount schemes in 1984. At the same time, Outboard Marine Corporation (OMC), one of the competitors of Brunswick, developed and introduced a new stern drive engine called Cobra. The engine was however not as successful as desired because the shift cable was said to be defective. This fact farther increased the market share of Brunswick. It is noticed that Brunswick as well as competitors of Brunswick offered conditional rebate schemes (cf. section I.A. of the Decision).

Brunswick's discount schemes were found not to be anti-competitive, because a price-cost test showed that prices were not below costs. Therefore competitors

[11] ZF Meritor, LLC vs. *Eaton* Corporation, Nos. 11-3301 & 11-3426, 2012 WL 4483899 (3d Cir. Sept. 28, 2012).

[12] Concord Boat Corporation v. *Brunswick* Corporation 309 F:3d 494 (8th Cir. 2002).

were not restricted by the pricing strategy of the dominant supplier.

Further decisions dealing with market-share contracts in the US are Tyco (2009) and Eisai (2014).[13] In *Tyco*, abusive effects of Tyco's rebates were argued and judged similar to *Eaton*. In *Eisai*, the price-cost test determined above-cost prices such that Eisai's rebates were not anticompetitive, similar to *Brunswick*.

Intel

One strongly disputed case regarding conditional discounts is Intel (2009).[14] In its decision, the Commission judged Intel for its anticompetitive agreements with original equipment manufacturers (OEMs) as well as a large retailer of consumer electronics. The Commission condemned Intel to the record fine of 1.06 billion EURO.

Intel manufactures computer processing units (CPUs). As a result of its technological developments Intel became the dominant firm in the market for CPUs. From 2002 to 2007, the only competitor on the x86 CPU market was Advanced Micro Devices, Inc. (AMD). AMD's chips were said to be qualitatively better than Intel's CPUs (cf. paragraph 150-159 of the Decision). In the given time period, Intel arranged exclusionary contracts with the German retailer of consumer electronics Media Saturn Group and specific conditional rebates in the contractual agreements with OEMs. More specifically, Dell, HP, Lenovo and further OEMs got rebates according to their sales, measured by the share which they purchased from Intel in comparison to AMD. On the one hand, Intel argued that the rebates were caused by the buyer power of large OEMs that played Intel and AMD off each other, see paragraph 885 of the Decision. On the other hand, however the Commission emphasized that Intel's CPUs were demanded by final consumers and therefore OEMs depended on Intel. That is, the rebates of Intel were said to have represented a threat to OEMs. The loss of Intel's rebates seems to have worked like penalties. For example, it is noted in paragraphs 955-957 that AMD offered HP one million CPUs for free, but HP only took 160 000 CPUs, to prevent the loss of Intel's rebates.

In its decision, the Commission applied the "as efficient competitor test", but

[13] Masimo Corp. v. *Tyco* Health Care Group, No. CV-02-4770 (MRP), 2006 WL 1236666 (C.D. Cal. Mar. 22, 2006), aff'd, 30 Fed. App'x 95 (9th Cir. 2009). *Eisai* Inc. v. Sanofi-Aventis US, LLC, No. 08-4168 (MLC) (D.N.J. Mar. 28, 2014).

[14] *Intel* v. Commission Decision, 2009, Case COMP/C-3/37.990.

noted that this test was not essential for the analysis. Market-share contracts were claimed to represent exclusionary discounts because large threshold levels can foreclose rival suppliers. The use of Intel's rebate schemes characterized an infringement of Article 102 of the Treaty on the European Union (TFEU).
The decision of the European Commission was inter alia criticized by Geradin (2010) and Mazzone and Mingardi (2011). They claim that there was no market foreclosure in the market for x86 CPUs. To the contrary, market shares of AMD even increased during the specified time period.[15]

These decisions are all connected by the fact that the markets are innovative, or at least have been, at about the same time where discounts were introduced. Innovations affect firm's efficiency. Therefore, the most efficient firm today may not be efficiently producing in the next years and may be surpassed by competitors. It is therefore questionable whether a supplier may use CRRs to enhance its own efficiency or to reduce efficiency gains of rivals or even to exclude rivals from the market.

1.2 Dynamic vs. static view

Innovative markets are often characterized by falling average costs, high rates of innovation, high entry and exit rates as well as economies of scale and consumption (Geradin et al., 2006; Posner, 2001). Foremost, but not only, in those industries the question arises whether a static legal analysis of antitrust cases is sufficient or whether a dynamic view, considering long-term changes due to market features, is rather necessary. Besides the mentioned articles of Scott-Morton (2012), Fumagalli and Motta (2015) as well as Geradin (2015), Ginsburg and Wright (2012) analyzes the question in how far antitrust authorities correctly regard and apply a dynamic view. They argue that antitrust authorities already consider dynamic effects, for example potential entry, as long as it is foreseeable. With regard to innovations, antitrust authorities do not seem to have a dynamic view. But, in this context, they explain that a dynamic view is not advisable. After all, the timing and extensiveness of innovations is not perfectly predictable. Thus, considering innovations may

[15] Cf. Mazzone and Mingardi (2011), Figure 4.

increase the potential of failures in the antitrust decisions.

In the economic literature, dynamic considerations are common. Especially in innovative markets, dynamic games are necessary to investigate long-run pricing strategies, R&D-decisions, changes in market structure and welfare. A basic reason is that decisions on entry, R&D-investments and pricing strategies are associated with different costs. Entry, for example, induces more costs and is therefore a rather long-run decision compared to changes in pricing strategies. These decisions are made at different speeds which is best represented in multi-stage games, cf. Motta (2004), chapter 8.5. Furthermore, innovative industries are often represented in multi-period games because rivals recognize quality jumps of their competitors' goods some periods after the initial firm increased its investment in R&D, see Sutton (2001, 2007). There is a large number of articles dealing with dynamic considerations as for example potential entry and decisions about R&D-investments.[16]

Besides those market dynamics, inter-temporal externalities are to be considered. For the analysis of these dynamics, multi-stage games are also necessary, due to their definition (Sutton, 2007). Demand-related advantages, so-called network externalities, network industries in conjunction with two-sided markets are for example studied by Katz and Shapiro (1986), Fudenberg and Tirole (2000), Doganoglu and Wright (2010) as well as Karlinger and Motta (2012).

Cost-related advantages, namely learning effects, are also inter-temporal externalities. Learning-by-doing can be denoted by *"the decline in production costs resulting from greater experience with the production process, typically measured by cumulated output"* (Irwin & Klenow, 1994). As such, they characterize a dynamic kind of scale economies (Grossman et al., 1989) and represent a specific kind of innovation (Gärtner, 2010). Learning effects can occur in different markets, inter alia in innovative ones because in the early stages of a new product, learning from experience can appear (Dasgupta & Stiglitz, 1988). Empirical evidence of learning-by-doing is for example given in the semi-conductor industry (Gruber, 1992, 1998;

[16] In context of exclusive dealing and potential entry, a large number of articles builds on Aghion and Bolton (1987) and Segal and Whinston (2000). R&D-investments or innovations in vertical structures are investigated by, for example, Stefanadis (1997), Banerjee and Lin (2003), and Y. Chen and Sappington (2010).

Hatch & Mowery, 1998; R. Cabral & Leiblein, 2001; L. M. B. Cabral & Riordan, 1994). As a specific subcategory, learning also occurs in the CPU market, see Cabrera (2008). Thus, learning-by-doing effects might have been present in the markets of the mentioned legal decisions (section 1.1).

The impact of learning-by-doing on pricing strategies, competition and welfare is predominantly analyzed in models with horizontal structures. L. M. B. Cabral and Riordan (1994, 1997) present that learning-by-doing can cause predatory pricing and market foreclosure. Predation can occur in the first period of a multi-period set-up because firms' costs in future periods are reduced by larger previous output. Therefore, it can be profitable to offer below-cost prices in the first period to benefit from higher efficiency gains in the following periods. In this context, below-cost prices can be extremely low, such that predatory pricing occurs. In this connection, predatory pricing can however be welfare enhancing due to the related efficiency gains. Furthermore, Lee (1975), Spence (1981) and Hollis (2002) show in different horizontal set-ups that learning effects can foreclose the market for potential entrants. Under the assumption that learning is firm-specific, Ross (1986) shows that Stackelberg competition can occur. That is, one firm becomes dominant due to its learning effects. Fudenberg and Tirole (1983) analyzes the impact of learning-by-doing on firm performance in a two-period model in which two firms compete with each other and consider the impact of their learning effects on the rival firm. More recent literature on learning effects focuses on incomplete information and regulatory issues (Lewis & Yildirim, 2002a, 2002b; Gärtner, 2010).

However, in the context of vertical supply chains the literature considering learning effects seems to be rather rare. To the best of our knowledge, Kourandi and Vettas (2011) is the first article that models learning effects in a vertical structure. They analyze a framework in which two upstream suppliers produce and sell imperfect substitutes to a single downstream firm that has (100%) buyer power. Considering learning-by-doing, Kourandi and Vettas show that under specific circumstances (regarding the degree of substitution), the downstream firm could prefer to exclusively purchase one product instead of both and thus exclude one supplier of the market.

Our models build on Kourandi and Vettas (2011), as we assume learning effects and vertical agreements, and focus on the effects that learning-by-doing causes in a vertical context. The following essays contribute to the literature because they present new economic impacts of learning-by-doing, especially according to the vertical structure, that influence the pricing strategies of upstream and downstream firms. Moreover, our models offer further explanations for the implementation of specific contract types, especially CRRs, by upstream firms, inter alia by a dominant firm.

1.3 Outline

This thesis deals with the contract choice of upstream suppliers as well as the consequences on competition and efficiency in a dynamic setting with inter-temporal externalities.

In the first model, a dominant upstream supplier and a non-strategic rival sell their products to a single downstream firm. The rival supplier faces learning effects which decrease the rival's costs with respect to its previous sales. Therefore, learning effects represent a dynamic competitive threat to the dominant supplier. In this set-up, the dominant supplier can react on inter-temporal externalities by specifying its contract to the downstream firm. The model shows that by offering market-share discounts, instead of simple two-part tariffs or quantity discounts, the dominant supplier maximizes long-run profits, and restricts the efficiency gains of its rival. If demand is linear, the market-share discount lowers consumer surplus and welfare.

The first model emphasizes that the dynamic threat of a rival causes the specific contract choice of a dominant supplier. The model particularly concentrates on conditional discounts. Yet, it is also shown that further contract types that reference the quantity of the rival can also lead to the same result. Taking the results of the first model into account, the second and third model analyze the contract choice of an eventually dominant supplier when its rival acts strategically and both suppliers face inter-temporal externalities. The contract types considered are simple two-part tariffs, own-quantity-referring contracts and market-share contracts.

The second model analyzes the strategic use of bilateral contracts in a sequential bargaining game. A dominant upstream supplier and its rival sequentially negotiate with a single downstream firm. The contract choice of the dominant supplier as well as the rival supplier's reaction are investigated. In a single-period sequential contracting game, menus of simple two-part tariffs achieve the industry profit maximizing outcome. In a dynamic setting where the suppliers sequentially negotiate in each period, the dominant supplier uses additional contractual terms that reference the rival's quantity. Due to the first-mover advantage of the first supplier, the rival supplier is restricted in its contract choice. The consequences of the dominant supplier's contract choice depend on bargaining power. In particular, market-share contracts can be efficiency-enhancing and welfare-improving whenever the second supplier has a relatively high bargaining position vis-à-vis the downstream firm. For a relatively low bargaining position of the rival supplier, the result is similar to the one determined in the first model. We show that results depend on the considered negotiating structure.

The third model introduces a simultaneous move game where two suppliers simultaneously negotiate with a common downstream firm. In a complete information setting where both suppliers get to know whether further negotiations fail or succeed, a single-period model solves for the industry-profit maximizing outcome as long as the contractual terms define at least a wholesale price and a fixed fee. In contrast, this collusive outcome cannot be achieved in a two-period model with inter-temporal externalities. We characterize the possible market scenarios, their outcomes and consequences on competition and efficiency. Our results demonstrate that in case a rival supplier is restricted in its contract choice, the contract specification of a dominant supplier can partially exclude the competitor. Whenever equally efficient suppliers can both strategically choose contract specifications, the rivals defend their market shares by adapting appropriate contractual conditions.

The final chapter provides an overview of the main findings and presents some concluding remarks.

Chapter 2

Limiting the Efficiency Gains of a Non-Strategic Rival

2.1 Introduction

Offering conditional discounts is a standard practice in supply chains. Upstream suppliers grant discounts to customers if their purchasing volume achieves or exceeds certain thresholds. In particular, these thresholds can be based on quantity targets, defining so-called quantity discounts, or percentages of total requirements, i.e. market-share discounts (Geradin, 2009; Faella, 2008; Ahlborn & Bailey, 2006). The significant difference between these discounts is actually given by the types of thresholds: In case of quantity discounts, the seller granting the discount offers lower prices only if the buyer purchases at least the given quantity threshold. That is, these contracts have a direct influence on the sales level of the discount-granting firm. In contrast, market-share discounts are offered, when at least a fraction ρ of the buyer's aggregate purchase is made by the discount-granting firm. Hence, market-share discounts have an (indirect) influence on all manufacturers' sales. They influence relative sales levels of competitors, but they cannot influence direct sales levels.

The impacts of these discounts on competitors, downstream firms, and final consumers vary: Besides pro-competitive reasons such as stimulating demand and consumer surplus, conditional discounts can also have anti-competitive effects (Inderst & Schwalbe, 2008). When granted by a dominant supplier, antitrust authorities claim that discount schemes characterize abusive pricing practices as they can be loyalty-inducing, lead to market foreclosure or consumer harm (Waelbroeck, 2005; Hovenkamp, 2006; Tom, Balto, & Averitt, 1999; Greenlee & Reitman, 2005). In the *Intel* Decision[1], for example, the European Commission identified Intel's conditional discounts to present an illegal practice in the x86 CPU market. In particular, the pricing practices of Intel, which is the dominant manufacturer in this market, allegedly restricted its rival AMD in competition/innovation incentives, and reduced consumer choice from 2002 to 2007.

Furthermore, the European Commission emphasized the exclusionary effects of conditional discounts and rebates in its Guidance Paper (2009). In relation to foreclosure effects in general, paragraph 24 states that exclusionary practices are not only those that exclude more or equally efficient competitors but also those that restrict less efficient competitors, because *'in the absence of an abusive practice such a competitor may benefit from demand-related advantages, such as network and learning effects, which will tend to enhance its efficiency'*.

In that regard, the question arises whether a specific discount scheme is more suitable to maximize profits of a dominant supplier and/or to restrict learning effects of competitors. As market-share discounts affect the relative purchase levels of competitors, they might represent better means to restrict the rivals' efficiency gains. However, market-share discounts do not influence total sales levels. Therefore, it is not obvious whether these discount schemes are more profitable than quantity discounts.

In this chapter, we examine the contract choice of a dominant upstream firm when its rival faces learning-by-doing. In our two-period model, the dominant upstream firm and its competitor sell their goods to a single downstream firm. We concentrate on the dominant firm's contracting decision, where we especially allow for these contractual terms which are often claimed to be anti-competitive. That is, we investigate (short term) market-share discounts, and quantity discounts. To highlight the potential differences in outcomes, we also analyze simple two-part tariffs, offered by the dominant firm.

In our setting, we suppose that there is one good which is solely produced by the dominant supplier. An imperfect substitute of this good is produced by a single competitor. We assume that this competitor of the dominant supplier is restricted in its pricing decision. Its wholesale price equals marginal costs. In the downstream

[1] *Intel v. Commission Decision, 2009, Case COMP/C-3/37.990.*

market, there is only one active firm. As we suppose complete information, this monopolistic firm maximizes profits, anticipating learning-by-doing of upstream suppliers.

As a first general result, we show that the contract decision of the dominant supplier is influenced by learning effects of the competitor. While the dominant supplier is indifferent between short-term two-part tariffs and discounts, when learning-by-doing is not taking place, it prefers only market-share discounts when learning-by-doing occurs. To be precise, the dominant supplier achieves maximum profits, given by the joint-profit maximizing outcome, when it grants short-term market-share discounts in both periods. In this regard, our model provides a novel explanation for the use of market-share discounts as opposed to no discount or quantity discounts.

In this context, we find that even though the competitive fringe's learning effects represent a competitive threat to the dominant supplier, this supplier will not use conditional discounts to exclude its rival.[2] Instead, the joint-profit maximizing outcome (and learning effects) occurs, because the dominant supplier's preferred contracts shift additional downstream rents upstream. Nevertheless, short-term quantity discounts and two-part tariffs lead to lower profits for the dominant supplier, and they induce larger learning effects for the competitive fringe. As a result, (only) market-share discounts restrict the rivals' learning effects, and hence its efficiency gains.

In case of linear demand, consumer surplus and welfare are lower when the dominant supplier offers its profit-maximizing market-share discount than when it uses two-part tariffs or quantity discounts. The reason is that in case of linear demand and two-part tariffs or quantity discounts, aggregate sales, consumer surplus and welfare are larger when the manufacturers become more efficient. As the market-share discount limits efficiency gains, these discounts lower consumer surplus and social welfare.

Related Literature

Our model is related to the economic literature on market-share and quantity discounts that explains pro- and anticompetitive effects of these contractual terms.

[2] As we consider the rival to be a competitive fringe, exclusion means that the sales of the fringe are zero.

A first model that examines the exclusionary effects of loyalty discounts is given by Ordover and Shaffer (2009). In their two-period model, there are two active sellers and a single buyer who prefers to purchase from both upstream firms. When at least one seller is financially constrained, equilibria exist in which loyalty discounts induce exclusion of this seller.
In addition, there are recent articles dealing with exclusion of a more efficient potential entrant. Erutku (2006) shows that rebates, granted by an incumbent, can lead to exclusion. Furthermore, Packalen (2011) and Z. Chen and Shaffer (2014) both build on the naked-exclusion framework by Rasmusen et al. (1991). In their models, they show that the incumbent can deter entry of a potential entrant by offering market-share discounts. In Chao and Tan (2015), a dominant firm can partially exclude a more efficient, capacity-constraint competitor by offering all-units discounts (retroactive quantity discounts). Semenov and Wright (2013) show that an incumbent can exclude a potential rival via a three-part quantity discounting contract. Our model relates to the literature as we analyze the effects of discount schemes of a dominant firm on a rival. However, exclusion or hinderance of the rival is not the first aim of this model.

As mentioned earlier, there are pro-competitive reasons for conditional discounts. Mills (2010) and Sloev (2010) show, for example, that market-share discounts can induce selling effort as well as innovation incentives in the downstream market. In addition, double marginalization can be eliminated by the use of conditional discounts. Inderst and Shaffer (2010) analyze a model with a dominant upstream firm and a competitive fringe that sell their goods to two competing downstream firms. In their model, market-share discounts eliminate downstream competition and lead to the joint profit maximizing outcome. That is, market-share discounts harm downstream competition. Kolay, Shaffer, and Ordover (2004) create a simple vertical structure where a single upstream firm sells its good to a monopolistic downstream firm. By offering all-units discounts without charging a fixed fee, double marginalization is eliminated.

Furthermore, Kolay et al. (2004) also show that all-units discounts lead to larger profits than incremental quantity discounts or two-part tariffs when there is asymmetric information about demand. Their result stems from the additional use of discount menus. Without contract menus but with simple discount schemes, recent studies claim that primarily market-share discounts represent a profitable alternative for dominant upstream firms when there is uncertainty about demand (Akgün and Chioveanu (2013) and Majumdar and Shaffer (2009)). In our framework, we do not allow for demand or cost uncertainties. Nevertheless, our article contributes to this literature as it shows that even without uncertainty, there are potential cases where market-share discounts are more profitable than different discount terms. Thus, our model presents an additional reason why dominant firms may specifically offer market-share discounts.

Karlinger and Motta (2012) further extends the literature on rebate schemes in addressing network effects. An incumbent produces and offers a network good to a number of asymmetric buyers when a more efficient rival tries to enter the market. The article shows inter alia that the incumbent is more likely to exclude the rival due to the advantages offered by intensive network externalities which the rival does not face. In our model, however, the rival is already an active firm and faces larger learning effects or consumption externalities (see section 2.4) than the dominant upstream firm. Thus, inter-temporal effects present a threat to the dominant firm, rather than an advantage.

To the best of our knowledge, there is no article dealing with learning-by-doing in the context of conditional discounts. Furthermore, there is no article addressing the question whether profitable discount schemes may partially restrict a dominant firm's rival in its efficiency gain. This model contributes to the literature as it analyzes the impact of discount schemes on learning effects of competitors.

The chapter is structured as follows. Section 2.2 describes the framework. In section 2.3.1, we solve the model for the case that inter-temporal externalities are not present. Here, contracts are examined where we consider simple two-part tariffs, quantity discounts and market-share discounts. The profit-maximizing contract terms in case of learning-by-doing are solved for in section 2.3.2. In section 2.3.3, we analyze welfare effects, and in section 2.4, some further extensions of the model are studied. Section 2.5 concludes.

2.2 Framework

We analyze conditional discounts in a supplier-retailer framework. A monopolistic downstream firm R purchases products of the upstream suppliers and resells them to

final consumers. There are two types of products, namely a specific good produced by the dominant upstream firm A only, and an imperfect substitute manufactured by a competitive fringe B. The contractual terms between the downstream firm and the dominant supplier A are the focus of our analysis.
We suppose there are two periods. Upstream firms A and B produce goods with constant marginal cost. While A has cost $c_A > 0$ in each period, marginal costs of the competitive fringe decrease over time. B has marginal cost c_{B1} in period 1 and $c_{B2} < c_{B1}$ in period 2, defined by

$$c_{B2} = \max\{0, c_{B1} - \lambda q_{B1}\},$$

where q_{B1} is the quantity sold by the competitive fringe B in period 1, and $\lambda \geq 0$ characterizes the learning parameter.[3] That is, analogue to L. M. B. Cabral and Riordan (1997), learning-by-doing is proportional to quantities sold in the first period.
The monopolistic downstream firm R purchases quantities q_{At}, q_{Bt} in period t. The downstream firm resells the products to final consumers where the inverse demand system in period $t = 1, 2$ is given by

$$P_A(q_{At}, q_{Bt}),$$
$$P_B(q_{At}, q_{Bt}).$$

We assume that $P_J(q_{At}, q_{Bt}) \in \mathcal{C}^1$ and $\frac{\partial P_J}{\partial q_{Jt}} < \frac{\partial P_J}{\partial q_{It}} < 0$ whenever $P_J(q_{At}, q_{Bt}) > 0$ for $J, I \in \{A, B\}$.[4] Thus, the impact of J's good on its final price is larger than the impact of the imperfect substitute on this price. Industry profits are assumed to be quasi concave and maximized by non-negative values.

The competitive fringe B is not capable of acting strategically. As the competition on its good is fierce, the wholesale price equals marginal cost $w_{Bt} = c_{Bt}$. The dominant supplier A however charges wholesale prices w_{At} and a fixed fee F_{At} for $t = 1, 2$. We concentrate on the contracts between A and downstream firm R.

In each period, we suppose that the dominant upstream firm can choose a two-part tariff (T), retroactive quantity discounts (Q), or market-share discounts (M)

[3] Note that these assumptions imply that the competitive fringe might be more, less or equally efficient as the dominant upstream firm.

[4] We suppose further that in case of two-times differentiable functions, the cross-derivatives are negative, that is $\frac{\partial^2 P_J}{\partial q_{Jt} \partial q_{It}} \leq 0$, with $\frac{\partial^2 P_J}{\partial q_{Jt}^2} \leq 0$ as well as $|\frac{\partial^2 P_I}{\partial q_{At} \partial q_{Bt}}| \leq |\frac{\partial^2 P_I}{\partial q_{Bt}^2}|$.

where each contract with (and without) discount schemes additionally defines fixed fees F_{At}. M's wholesale prices in case of quantity and market-share discounts w_{At}^{Q}, w_{At}^{M} are characterized by

$$w_{At}^{\mathrm{Q}} = \begin{cases} w_{\mathrm{Q}t}, & \text{if } q_{At} \geq q_{At}^* \\ w_t, & \text{if } q_{At} < q_{At}^* \end{cases}, \text{ and } \quad w_{At}^{\mathrm{M}} = \begin{cases} w_{\mathrm{M}t}, & \text{if } \frac{q_{At}}{q_{At}+q_{Bt}} \geq \rho_t^* \\ w_t, & \text{if } \frac{q_{At}}{q_{At}+q_{Bt}} < \rho_t^* \end{cases},$$

where $w_{\mathrm{Q}t}, w_{\mathrm{M}t} < w_t$. The respective threshold levels are q_{At}^* which corresponds to the quantity threshold for the quantity discount and ρ_t^*, that is the percentage R has to purchase for paying the lower price $w_{\mathrm{M}t}$ in case of a market-share discount.

Timing of the game

The timing of the two-period game is as follows. In period one, the dominant upstream firm decides about a contract type and offers such a contract to the downstream firm. The competitive fringe sells its goods at a price of c_{B1}. The downstream firm then accepts or rejects the offer, purchases and resells the products for the first period.[5] Once the first-period purchase is completed, learning-by-doing occurs.

In period 2, supplier A offers a second, single-period contract. The downstream firm decides whether to accept or reject this second contract and will set final prices for period 2.

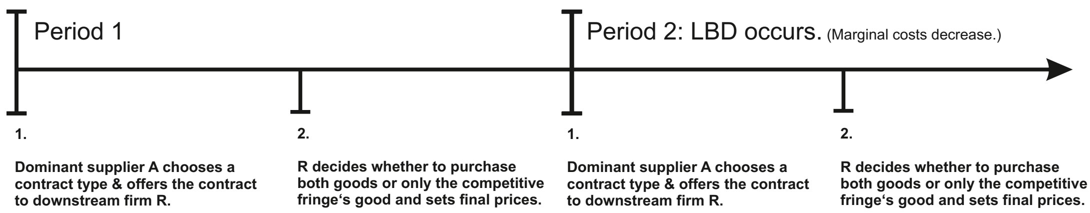


Figure 2.1: Timing of the game.

The structure of demand and costs is common knowledge to downstream and upstream firms. Both the dominant upstream supplier and the downstream firm anticipate B's learning-by-doing and maximize profits. The competitive fringe in contrast gets zero profit by definition. We solve the model by backwards induction to determine the sub-game perfect equilibria.

[5]Depending on the accepted contract, the downstream firm sells either both goods if it accepted or only the fringe's good if it rejected the dominant supplier's offer.

2.3 Model

2.3.1 Benchmark case: no learning

We first examine the case where learning-by-doing effects do not occur. This is either the case because these effects do not appear in a specific market, or because they are not observable, let alone verifiable. The learning parameter λ equals zero.

A single-period analysis is sufficient to derive the profit-maximizing contract. The optimal decision in one period is repeated in every period. Therefore, the comparison of a single-period two-part tariff with a quantity discount and a market-share discount already shows the profit maximizing contract choice of the dominant supplier, when learning does not occur.

When the dominant supplier offers a simple two-part tariff $(w_{At}^{\mathrm{T}}, F_{At}^{\mathrm{T}})$ in a single-period model (t=1,2), the downstream firm decides whether to accept or reject the contract offer according to its related profits. If the two-part tariff is accepted, the downstream firm decides upon quantities q_{At}, q_{Bt} according to the wholesale price w_{At}. The optimal downstream gross profit is then given by

$$\pi_{Rt}(q_{At}, q_{Bt}) = (P_A(q_{At}, q_{Bt}) - w_{At})q_{At} + (P_B(q_{At}, q_{Bt}) - c_{B1})q_{Bt} \tag{2.1}$$

where $q_{At} = q_{At}(w_{At})$ and $q_{Bt} = q_{Bt}(w_{At})$ are the profit maximizing quantity levels.[6]

If instead the downstream firm rejects the contract, it earns the outside option $\pi_{Rt}^{o}(c_{B1})$, given by

$$\pi_{Rt}^{o}(c_{B1}) = \max_{q_{Bt}}(P_B(0, q_{Bt}) - c_{B1})q_{Bt}. \tag{2.2}$$

Maximizing own profits $\pi_{At}(w_{At}) = q_{At}(w_{At})(w_{At} - c_A) + F_{At}$, the dominant upstream firm anticipates R's quantity choice and participation constraint, which is

$$\pi_{Rt}(q_{At}(w_{At}), q_{Bt}(w_{At})) - F_{At} \geq \pi_{Rt}^{o}(c_{B1}).$$

The profit-maximizing two-part tariff leads to the joint-profit maximizing quantities q_{At}^{I}, q_{Bt}^{I} and is given by $w_{At}^{\mathrm{T}} = c_A$ and $F_{At}^{\mathrm{T}} = \pi_t^{I}(c_{B1}) - \pi_{Rt}^{o}(c_{B1})$, where $\pi_t^{I}(c_{B1})$

[6] As there is no change in the competitive fringe's costs, the fringe faces marginal cost c_{B1} in both periods.

is the maximum industry profit, given by

$$\pi_t^I(c_{B1}) = \max_{q_{At}, q_{Bt}} \ (P_A(q_{At}, q_{Bt}) - c_A)q_{At} + (P_B(q_{At}, q_{Bt}) - c_{B1})q_{Bt}.$$

The dominant upstream firm earns $\pi_{At}^{\mathrm{T}}(c_{B1}) = \pi_t^I(c_{B1}) - \pi_{Rt}^o(c_{B1})$ and the downstream firm $\pi_{Rt}^{\mathrm{T}}(c_{B1}) = \pi_{Rt}^o(c_{B1})$, in period $t = 1, 2$.

Accordingly, simple two-part tariffs already lead to maximum profits for the dominant upstream firm. Larger upstream profits than given by the joint-profit maximizing outcome are not feasible because the dominant supplier needs to leave $\pi_{Rt}^o(c_{B1})$ to the downstream firm R, to achieve R's acceptance.

Therefore, granting conditional discounts does not improve the already best result for the dominant upstream firm. Defining additional discount conditions leads to the same outcome as the profit-maximizing two-part tariff.[7]

In the following, we introduce learning-by-doing by the competitive fringe to analyze the influence of this competitive threat on the contract decision of the dominant supplier.

2.3.2 Learning-by-doing

We consider a model with two periods where the rival of the dominant supplier faces learning effects.[8] Marginal costs of the dominant supplier are constantly given by $c_A > 0$. In the first period, marginal costs of the competitive fringe are given by $c_{B1} > 0$. Due to learning effects, the fringe's marginal costs in period 2 are $c_{B2} < c_{B1}$. We suppose here, that $c_{B2}(q_{B1}) = c_{B1} - \lambda q_{B1} > 0$, respectively $\lambda < \frac{c_{B1}}{q_{B1}^o}$, where $q_{B1}^o > 0$ is the quantity sold of B's good, when the downstream firm only deals with the competitive fringe.[9]

[7] In particular, the profit-maximizing quantity discounts are given by $q_{At}^* = q_{At}^I$, an unattractively large un-discounted price w_t, and the discounted price w_{Qt} as well as fixed fee F_{At} given by $\max_{q_{Bt}} \ \pi_{Rt}(q_{At}^*, q_{Bt}) = \pi_{Rt}^o(c_{B1})$. The (single) profit-maximizing market-share discount is given by $\rho_1^* = \frac{q_{At}^I}{q_{At}^I + q_{Bt}^I}$, an unattractively large w_t, the discounted wholesale price $w_{\mathrm{M}t} = c_A$, and the fixed fee $F_{At}^{\mathrm{M}} = \pi_2^I(c_{B2}) - \pi_{Rt}^o(c_{B2})$.

[8] Section 2.4 shows that the qualitative results characterized in the previous section also hold for the case where both suppliers face learning effects.

[9] Even if $c_{B1} > c_A$, the fringe's marginal cost in $t = 2$ might be larger or lower than A's cost c_A. That is, the competitive fringe can become more efficient than the dominant supplier. In addition, note that due to the considered inverse demand system, the optimal first-period purchase level q_{B1} of the fringe's good never exceeds the 'outside option' level q_{B1}^o.

Solving for the optimal contracts offered by the dominant supplier, we compare both the (short-term) contracts which specify a fixed fee, wholesale price, and potentially include conditional discounts.[10]

We solve by backwards induction and start with the second period.

As the second-period decision is analogous to the single-period short-term decision in section 2.3.1, the dominant supplier will offer either a two-part tariff, quantity discount or market-share discount, as all these contracts lead to maximum second-period profits. Hence, the dominant upstream firm earns $\pi_{A2}(c_{B2}) = \pi_2^I(c_{B2}) - \pi_{R2}^o(c_{B2})$ in the second period whilst the downstream firm gets its outside option $\pi_{R2}^o(c_{B2})$, both depending on c_{B2}.

Solving for the optimal decision in the first period, all firms take into account the second-period outcome in their optimization. As the marginal cost c_{B2} depends on the first-period quantity q_{B1} sold by the competitive fringe, the dominant supplier as well as the downstream firm maximize long-run profits to solve for their optimal quantity, and contract decisions. Long-run profits of firm J, $J = A, R$ are defined by the present value $\Pi_J = \pi_{J1} + \delta\pi_{J2}$, where single-period profits are defined by π_{Jt} $(t = 1, 2)$, and δ represents the (time-)discount factor.

First, as second-period profits of the downstream firm are given by its outside option $\pi_{R2}^o(c_{B2})$, this firm prefers larger learning effects of the competitive fringe B, because learning effects decrease marginal costs of B, that is the wholesale price paid by the downstream firm for a unit of B's good. In particular, with the help of the Envelope Theorem, the extent of this effect is given by

$$\frac{\partial \pi_{R2}^o}{\partial q_{B1}} = -\lambda \frac{\partial \pi_{R2}^o}{\partial c_{B2}} = \lambda q_{B2}^o > 0,$$

where q_{B2}^o are second-period sales of the competitive fringe in the (long-run) outside option.

Second, the dominant supplier's second-period profits decrease when learning-by-doing increases (that is, when q_{B1} increases). In particular, this effect is given by

$$\frac{\partial \pi_{A2}}{\partial q_{B1}} = -\lambda \cdot \left(\frac{\partial \pi_2^I}{\partial c_{B2}} - \frac{\partial \pi_{R2}^o}{\partial c_{B2}}\right) = -\lambda \cdot (q_{B2}^o - q_{B2}^I) < 0.$$

As the joint-profit maximizing sales level q_{B2}^I of the competitive fringe is smaller

[10] Long-term contracts in which contract terms for both periods are defined in period one, are discussed in section 2.4.

than q^o_{B2} (by construction of the demand system), the derivative $\frac{\partial \pi_{A2}}{\partial q_{B1}}$ is negative.[11] Hence, the larger learning effects are, the larger is the competitive threat to the dominant supplier.

Together, there occur two opposing effects on second-period outcomes: First, the downstream firm supports learning-by-doing by purchasing more of the competitive fringe's good. Second, the dominant supplier tends to restrict learning as it presents a competitive threat and decreases upstream profits in the first glance.

In the following, we analyze the decision of the dominant supplier in the first period. We start with the case where the dominant upstream firm offers a two-part tariff in period 1. Then, we analyze the optimal decision if the dominant upstream firm offers a quantity discount, or if it offers a market-share discount in period 1. We compare these results to derive the optimal contract choice and the related outcome.

To ensure that long-run profits have a unique maximum in this context, we make the following additional assumption.

Assumption 2.1.
Long-run joint profits are given by

$$\Pi_I(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - c_A)q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1} + \delta\pi^I_2(c_{B2}(q_{B1})),$$

long-run downstream profits are given by $\Pi_R(q_{A1}, q_{B1}) - F_{A1}$*, where*

$$\Pi_R(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - w_{A1})q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1} + \delta\pi^o_{R2}(c_{B2}(q_{B1}))$$

according to the pricing structure, respectively the wholesale price w_{A1}*. Both are assumed to be concave. That is, the Hessian matrices of* Π_I *and* Π_R *are negative definite.*

Note that sub-game perfect equilibria are on the focus. In this context, gross long-run profits of the downstream firm $\Pi_R(q_{A1}, q_{B1})$ imply the optimal outcome for the second period. That is, the second-period contract is already included in the calculations. Second-period prices, especially the fixed fee F_{A2}, are considered to be paid and are not included in these long-run profits.

[11] A proof of this relation is given in section 2.6.1.

Two-part tariffs

We consider first that the dominant upstream supplier offers a simple two-part tariff in period 1. In the second period, profits are given by $\pi_{A2}(c_{B2})$ for the dominant supplier, and $\pi^o_{R2}(c_{B2})$ for the downstream firm, independent of the contract structure in period 2. Without loss of generality, we suppose here that the dominant supplier offers a two-part tariff in each period.

Solving the game by backwards induction, we start with the downstream sector. The downstream firm R accepts the two-part tariff in period 1 only if related long-run profits exceed the long-run outside option, which is 'purchasing only from the competitive fringe' (at least in period 1), given by

$$\Pi^o_R = \max_{q_{B1}}(P_B(0, q_{B1}) - c_{B1})q_{B1} + \delta\pi^o_{R2}(c_{B2}(q_{B1})). \tag{2.3}$$

When R accepts the two-part tariff, it maximizes net long-run profits

$$\Pi_R(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - w_{A1})q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1} + \delta\pi^o_{R2}(c_{B2}(q_{B1})) \tag{2.4}$$

with respect to both quantities. There are no additional constraints, thus both optimal quantity levels $q_{A1}(w_{A1})$, $q_{B1}(w_{A1})$ depend on the wholesale price w_{A1}, and are characterized by the first-order conditions

$$\frac{\partial\Pi_R}{\partial q_{A1}} = \frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1}, q_{B1}) - w_{A1} = 0, \tag{2.5}$$

$$\frac{\partial\Pi_R}{\partial q_{B1}} = \frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda\frac{\partial\pi^o_{R2}}{\partial c_{B2}} = 0. \tag{2.6}$$

Differentiating (2.5), (2.6) with respect to w_{A1} shows that an increase in w_{A1} decreases q_{A1} but increases q_{B1} (cf. section 2.6.1). This relation is caused by the assumption of imperfect substitutes. When the wholesale price of the dominant supplier's good increases, the downstream firm would purchase less of this good and substitute with the other. Hence, R would purchase more of the fringe's good instead.

The dominant upstream firm decides about the profit-maximizing wholesale price and fixed fee, anticipating this quantity choice as well as the participation constraint of the downstream firm. That is, the dominant supplier maximizes its long-run profits Π_A subject to the participation constraint $\Pi_R(q_{A1}(w_{A1}), q_{B1}(w_{A1})) -$

$F_{A1} \geq \Pi_R^o$.[12] Here, A's long-run profits are given by

$$\Pi_A = q_{A1}(w_{A1})(w_{A1} - c_A) + F_{A1} + \delta(\pi_2^I(c_{B2}) - \pi_{R2}^o(c_{B2})).$$

These long-run profits include the optimal second-period profits depending on c_{B2}, and therefore on $q_{B1}(w_{A1})$, and first-period profits which depend on w_{A1} and F_{A1}.

As the participation constraint is binding in equilibrium, the fixed fee shifts all additional rents upwards, and the wholesale price is used to maximize (combined) long-run profits. The optimal contract terms are given as follows.

Lemma 2.1 (Two-part tariffs).
When the dominant upstream firm offers short-run two-part tariffs, the profitable contracts are defined by

- w_{A1}^T *given by* $w_{A1}^T = c_A + \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}/\partial w_{A1}}{\partial q_{A1}/\partial w_{A1}}$
  and $F_{A1}^T = \max_{q_{A1}, q_{B1}} \Pi_R(q_{A1}, q_{B1}) - \Pi_R^o$, *in period 1,*
- $w_{A2}^T = c_A$ *and* $F_{A2}^T = \pi_2^I(c_{B2}^T) - \pi_{R2}^o(c_{B2}^T)$, *in period 2.*

Proofs are delegated to section 2.6.1.
We denote $q_{A1}^{\mathrm{T}} = q_{A1}(w_{A1}^{\mathrm{T}})$, $q_{B1}^{\mathrm{T}} = q_{B1}(w_{A1}^{\mathrm{T}})$ the first-period quantities, $c_{B2}^{\mathrm{T}} = c_{B1} - \lambda q_{B1}^{\mathrm{T}}$ the marginal cost of B in period 2, and q_{A2}^{T}, q_{B2}^{T} the second-period quantities at equilibrium, when the dominant supplier offers the defined two-part tariffs.

As $\frac{\partial q_{B1}/\partial w_{A1}}{\partial q_{A1}/\partial w_{A1}}$ is negative and $\frac{\partial \pi_{A2}}{\partial c_{B2}}$ is positive for all c_{B2}, the optimal wholesale price of the first-period two-part tariff is smaller than marginal cost c_A. That is, in contrast to the benchmark situation, the dominant upstream firm uses below-cost pricing in the first period, to maximize long-run profits. Here, the intuition for below-cost pricing differs from the one in the literature on learning-by-doing (see section 1.2). In the present vertical set-up, the dominant firm's below-cost pricing strategy is caused by the quantity choice of the downstream firm. Furthermore, the intuition lies in the assumptions of imperfect substitutes and complete information.[13]

[12] As upstream profits are larger when A sells its good in both periods, it will always offer contract terms that achieve R's acceptance in both periods.

[13] Note that complete information refers to the downstream firm's knowledge about the fringe's learning-by-doing effects. When the downstream firm does not know about learning-by-doing, R would purchase less of the fringe's good.

Suppose for a moment that the dominant supplier would set the first-period wholesale price equal to marginal cost c_A, analog to the benchmark case. Then, the downstream firm would have chosen quantities $q_{A1}(c_A)$, $q_{B1}(c_A)$ according to the following first-order conditions

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{C1} + P_A(q_{A1}, q_{B1}) - c_A = 0,$$
$$\frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}q_{C1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda\frac{\partial \pi^o_{R2}}{\partial c_{B2}} = 0.$$

Yet, as the (overall) maximum profit for the dominant supplier is given in case of maximum joint profits, the supplier prefers the quantities which are given by the first-order conditions:

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1}, q_{B1}) - c_A = 0,$$
$$\frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda\frac{\partial \pi^I_2}{\partial c_{B2}} = 0.$$

Note that $\frac{\partial \pi^o_{R2}}{\partial c_{B2}} < \frac{\partial \pi^I_2}{\partial c_{B2}} < 0$. Hence, when the dominant supplier offers a two-part tariff including $w_{A1} = c_A$, the downstream firm chooses the quantity $q_{B1}(c_A)$, which is larger than the joint-profit maximizing level and therefore larger than the quantity which is preferred by the dominant supplier. The downstream firm would provoke a level of learning effects for the competitive fringe, which is larger than preferable for the dominant supplier. In addition, the sales level of $q_{A1}(c_A)$ would be smaller than the preferable level for the upstream firm. That is, the joint-profit maximizing result does not occur for a wholesale price equal to marginal cost. This difference to the benchmark case occurs because firms anticipate the influence of learning effects on second-period profits.

By decreasing the wholesale price below cost, the dominant upstream firm makes the downstream firm choose a lower quantity q_{B1} and larger level q_{A1} than in case of $w_{A1} = c_A$. Below-cost pricing is thus used by the dominant supplier to reduce the competitor's sales and to approach the joint-profit maximizing outcome which maximizes upstream profits.

However, the actual joint-profit maximizing outcome will not be reached: Decreasing the wholesale price w_{A1} below cost increases the long-run downstream profits and therefore increases the fixed fee F_{A1}. A's second-period profits also increase when q_{B1} decreases. Yet, as the margin $w_{A1} - c_A$ is negative and the quantity level q_{A1} increases when w_{A1} decreases, A's first-period variable profits are negative and decreasing. Therefore, long-run profits will first increase, when the dominant supplier decreases its wholesale price below cost. This is because the positive effect on F_{A1} and second-period profits exceeds the negative effect on first-period variable profits. There is a threshold level for which the negative and positive effects offset each other. When the wholesale price falls below this level, the negative effect dominates and long-run profits decrease. As can be shown, the wholesale price, which leads to the joint-profit maximizing level of q_{B1}, is lower than the threshold level. Thus, it is not profitable for the dominant supplier to achieve quantity q^I_{B1}. The profitable first-period two-part tariff leads to q^{T}_{B1} which is larger than q^I_{B1}.[14]

Proposition 2.1 (Learning effects and two-part tariffs).
In contrast to the benchmark case, the dominant supplier's profit-maximizing two-part tariff does not lead to the joint-profit maximizing outcome when learning-by-doing occurs. As the first-period quantity q^T_{B1} sold by the competitive fringe is larger than the joint-profit maximizing level q^I_{B1}, the competitive fringe's marginal costs c^T_{B2} are smaller in case of two-part tariffs, than in case of maximum joint profit.

The proof is delegated to the appendix, section 2.6.1.
The overcompensation of learning-by-doing which is initiated by the profit maximization of the downstream firm, cannot be influenced to achieve the quantities q^I_{A1} and q^I_{B1} which are preferable from the dominant supplier's perspective. The quantity q^{T}_{B1} is larger than q^I_{B1} for $\lambda > 0$, because it is not profitable for the dominant supplier to charge a lower wholesale price than w^{T}_{A1}.

In the following, we derive the dominant upstream firm's profit-maximizing quantity discount and market-share discount in period 1, and analyze whether these discounts influence the competitive fringe's learning effects.

Quantity discounts

We now consider the case, where the dominant supplier offers a quantity discount in period 1. Without loss of generality we suppose that the upstream firm offers a quantity discount in period 2 as well. Second period profits are given by $\pi_{A2}(c_{B2})$ and $\pi^o_{R2}(c_{B2})$.

A quantity discount in period 1 is defined by a quantity threshold q^*_{A1}, an un-

[14]Note that by decreasing w_{A1}, the dominant supplier can never achieve both, q^I_{A1} and q^I_{B1}.

discounted wholesale price, a discounted wholesale price and the fixed fee F^{Q}_{A1}. When the downstream firm purchases less than q^*_{A1} units of the dominant supplier's good, it has to pay the un-discounted wholesale price w_1 per unit. If it purchases at least q^*_{A1} units of A's good, the wholesale price is given by the discounted price $w_{\mathrm{Q}1}$ per unit. As the dominant supplier has no incentive to offer a discount scheme which is then rejected by the single buyer, the un-discounted wholesale price w_1 will be unattractively large. That is, accepting the contract and purchasing less than the quantity target q^*_{A1} leads to lower profits for the downstream firm, than the outside option Π^o_R. Therefore, the downstream firm only decides whether to accept the quantity discount purchasing exactly or more than q^*_{A1} units of the dominant supplier, or to reject the offer and earn Π^o_R. When R accepts the discount scheme and purchases more than q^*_{A1} units, it chooses the same quantities, depending on w_{A1}, as in the case of two-part tariffs. Hence, maximizing upstream profits would lead to the same prices and outcome as the profit-maximizing two-part tariff, where $q^*_{A1} < q^{\mathrm{T}}_{A1}$, in this case. When, in contrast, the discount condition is binding (R purchases exactly q^*_{A1} units of A), the downstream firm chooses $q_{B1}(q^*_{A1})$ with respect to q^*_{A1}, according to

$$\frac{\partial \Pi_R}{\partial q_{B1}} = \frac{\partial P_A}{\partial q_{B1}} q^*_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q^*_{A1}, q_{B1}) - c_{B1} - \delta\lambda \frac{\partial \pi^o_{R2}}{\partial c_{B2}} = 0. \tag{2.6}$$

Similar to the optimization in case of two-part tariffs, the downstream firm anticipates the fringe's learning effects when choosing the quantity level q_{B1}. The influence of learning is given by $\lambda \frac{\partial \pi^o_{R2}}{\partial c_{B2}}$. In contrast to two-part tariffs, where both quantities depend on the wholesale price, the downstream firm chooses only q_{B1}, and only with respect to the fixed level q^*_{A1}. In particular, the quantity forcing effect of these discount schemes gives the dominant supplier a more direct influence on q_{A1}, compared to two-part tariffs. The dominant supplier maximizes long-run profits

$$\Pi_A = q^*_{A1} \cdot (w_{\mathrm{Q}1} - c_A) + F_{A1} + \delta \pi_{A2}(c_{B2})$$

subject to the participation constraint $\Pi_R(q^*_{A1}, q_{B1}(q^*_{A1})) - F_{A1} \geq \Pi^o_R$. Solving the constrained optimization problem leads to the following profit-maximizing quantity discount terms.

Lemma 2.2 (Quantity discounts).
The profit-maximizing (binding) quantity discounts are given by

- $(w_{\mathrm{Q}1}, F^Q_{A1})$ *and* q^*_{A1} *equal to* q^T_{A1} *in period 1,*

- (w_{Q2}, F^{Q}_{A2}) *and* q^{*}_{A2} *equal to* q^{I}_{A2}*, in period 2,*

where the tuples (w_{Q1}, F^{Q}_{A1}) *and* (w_{Q2}, F^{Q}_{A2}) *are defined by* $F^{Q}_{A1} = \Pi_R(q^{T}_{A1}, q^{T}_{B1}) - \Pi^{o}_{R}$ *and* $F^{Q}_{A2} = \pi_{R2}(q^{T}_{A2}, q^{T}_{B2}) - \pi^{o}_{R2}(c_{B2})$*, where* $\Pi_R(q^{T}_{A1}, q^{T}_{B1})$ *depends on* w_{Q1}*, and* $\pi_{R2}(q^{T}_{A2}, q^{T}_{B2})$ *depends on* w_{Q2}*.*

Proofs can be found in section 2.6.1.

The profit-maximizing outcome is characterized by the quantity levels q^{T}_{A1}, q^{T}_{B1}, and $q^{I}_{A2}(c^{T}_{B2})$, $q^{I}_{B2}(c^{T}_{B2})$. Hence, both the binding and non-binding discount conditions lead to the same result as a simple two-part tariff.

In both cases (binding, non-binding), the discount condition causes an over-specification of contract terms. In comparison to two-part tariffs, the dominant supplier faces an additional instrument, namely q^{*}_{A1}, when it offers a quantity discount. However, in case of both the binding and non-binding quantity discount, this additional instrument characterizes an over-specification of contract terms. For the non-binding condition, this is because q^{*}_{A1} has no influence on the downstream firm's optimization. For the binding discount condition, q^{*}_{A1} serves as a control variable, but it is the only one to influence the downstream quantity choice q_{B1}. Hence, the discounted wholesale price as well as the fixed fee achieve R's acceptance, but have no influence on the quantity choice of the downstream firm. Defining a discounted price w_{Q1} as well as a fee F^{Q}_{A1} is therefore an over-specification of contract terms. Setting no fixed fee, and choosing the related discounted wholesale price according to $\Pi_R(q^{\mathrm{T}}_{A1}, q^{\mathrm{T}}_{C1}) = \Pi^{o}_{R}$, where $q^{*}_{A1} = q^{\mathrm{T}}_{A1}$, is for example one specific, profit-maximizing contract. An alternative combination would be $w_{Q1} = c_A$ and $F^{\mathrm{Q}}_{A1} = \Pi_R(q^{\mathrm{T}}_{A1}, q^{\mathrm{T}}_{C1})|_{w_{Q1}=c_A} - \Pi^{o}_{R}$.

Proposition 2.2 (Learning effects and quantity discounts)**.**
As profit-maximizing quantity discounts lead to the same outcome as two-part tariffs, the competitive fringe's marginal costs are c^{T}_{B2}*. Hence, the degree of B's learning-by-doing is the same as in case of profit-maximizing two-part tariffs.*

When the dominant supplier offers quantity discounts (as one type of conditional discounts), these do not restrict the competitive fringe's learning-by-doing. Instead, this form of conditional discounts leads to the outcome that would also be generated without a discount scheme.

Quantity discounts only induce an advantage over two-part tariffs, as they can specify a discounted wholesale price above marginal cost c_A (and a related fixed fee). By offering such a contract, the dominant supplier earns the same profit as in case of two-part tariffs. Therefore, quantity discounts characterize an alternative pricing scheme without below-cost prices.

Market-share discounts

A market-share discount in period 1 defines a share threshold ρ_1^*, the discounted wholesale price w_{M1}, an un-discounted price w_1 as well as a fixed fee F_{A1}^{M}. Compared to quantity discounts, market-share discounts have no direct influence on absolute quantity levels, but relative levels. In the following, we suppose that the dominant supplier offers a market-share discount in period 1, and, without loss of generality, in period 2 as well.

In the first period, the downstream firm R decides whether to accept the contract, and optionally the discount, or reject the offer. As the dominant firm induces R to fulfill the discount condition, the un-discounted wholesale price is relatively large, leading to (long-run) downstream profits below Π_R^o. Maximizing profits $\Pi_R(q_{A1}, \frac{1-\rho_1}{\rho_1} q_{A1})$ subject to the discount condition $\rho_1 \geq \rho_1^*$, the downstream firm can decide to purchase more or exactly at the threshold. When the downstream firm prefers to purchase a larger share of the dominant firm's product, the optimization problem is similar to the case of two-part tariffs. Yet, in case of a binding discount condition, the downstream firm purchases exactly at the share threshold ρ_1^*. Accepting A's contract, this means that the downstream firm maximizes profits only with respect to aggregate purchase while taking ρ_1^* as given. The first-order condition representing optimal purchase in case of a binding discount is given by

$$\begin{aligned}\frac{\partial \Pi_R}{\partial q_{A1}} &= \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} \frac{1-\rho_1}{\rho_1} q_{A1} + P_A(q_{A1}, \frac{1-\rho_1}{\rho_1} q_{A1}) - w_{M1} \\ &+ \frac{1-\rho_1}{\rho_1}\left(\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho_1}{\rho_1} q_{A1} + P_B(q_{A1}, \frac{1-\rho_1}{\rho_1} q_{A1}) - c_{B1} - \delta\lambda \frac{\partial \pi_{R2}^o}{\partial c_{B2}}\right) = 0.\end{aligned} \tag{2.7}$$

The implicit function theorem shows that quantity q_{A1} decreases, when the wholesale price w_{M1} increases. As the quantity sold by the competitive fringe equals $q_{B1} = \frac{1-\rho_1^*}{\rho_1^*} q_{A1}$, this quantity level also decreases when w_{M1} increases. Compared to the previous contracts, the binding market-share discount hinders the downstream firm to substitute goods when the wholesale price increases. Instead, this firm would lower both quantity levels to the same, proportional extent.

Furthermore, equation (2.7) shows that the purchase level q_{A1} depends not only on the discounted wholesale price w_{M1}, but also on the share ρ_1^*. For that reason the dominant upstream supplier possesses two instruments to control for q_{A1} and $q_{B1}(=\frac{1-\rho_1^*}{\rho_1^*}q_{A1})$ when it maximizes its profits Π_A. Namely, ρ_1^* and w_{M1} control the quantity levels, and F_{A1}^M is used to shift rents upwards.

Lemma 2.3 (Market-share discounts).
The profit maximizing binding market-share discounts are given by

- $\rho_1^* = \frac{q_{A1}^I}{q_{A1}^I + q_{B1}^I}$,
  w_{M1} *given by* $w_{M1} = c_A + \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}} \frac{1-\rho_1^*}{\rho_1^*}$,
  $F_{A1}^M = (P_A(q_{A1}^I, q_{B1}^I) - w_{M1})q_{A1}^I + (P_B(q_{A1}^I, q_{B1}^I) - c_{B1})q_{B1}^I + \delta\pi_{R2}^o(c_{B2}^I) - \Pi_R^o$

  in the first period, and

- $\rho_2^* = \frac{q_{A2}^I}{q_{A2}^I + q_{B2}^I}$,
  $w_{M2} = c_A$,
  $F_{A2}^M = \pi_2^I(c_{B2}^I) - \pi_{R2}^o(c_{B2}^I)$

  in the second period.

Proofs are delegated to the appendix, section 2.6.1.
The first-order conditions of the dominant supplier's optimization problem are given by

$$w_{M1} - c_A - \delta\lambda \frac{1-\rho_1^*}{\rho_1^*} \frac{\partial \pi_{A2}}{\partial c_{B2}} = 0 \tag{2.8}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho_1^*}{\rho_1^*} q_{A1} + P_B(q_{A1}, \frac{1-\rho_1^*}{\rho_1^*} q_{A1}) - c_{B1} - \delta\lambda \frac{\partial \pi_2^I}{\partial c_{B2}} = 0. \tag{2.9}$$

Inserting these conditions in the downstream firm's first-order condition (2.7) shows that the optimal quantity choice implicates the joint-profit maximizing levels q_{A1}^I, q_{B1}^I, as well as q_{A2}^I, q_{B2}^I.

Furthermore, as $\frac{\partial \pi_{A2}}{\partial c_{B2}}$ is positive for all $c_{B2} \in [0, c_{B1}]$, the discounted wholesale price is larger than marginal cost. This result stems from the fact that the binding market-share discount restricts the downstream firm's relative purchase levels: If the downstream firm increases its purchase of the fringe's good, it needs to increase the purchase of A's good, too. Suppose for a moment that the dominant upstream supplier would offer a discount condition that specifies ρ_1^* (as given in the lemma) and a wholesale price which equals marginal costs c_A, similar to the benchmark case. Inserting the dominant firm's first-order condition (2.9) as well as $w_{A1} = c_A$ into the downstream firm's decision, which is given by equation (2.7), characterizes the downstream firm's quantity choice, in this case. However, in comparison to the joint-profit maximizing levels, the purchase levels of the downstream firm would be larger. The reason for this result is that the downstream firm anticipates the fringe's learning effects. Anticipating its second-period profits, the downstream firm purchases a larger level of q_{B1}, and due to the binding share threshold ρ_1^* a larger level of q_{A1}. Raising the wholesale price therefore decreases both quantity levels, leading to the joint-profit maximizing quantity as well as price levels which are preferable for the dominant upstream firm. Thus, the profit-maximizing market-share discounts yield the joint-profit maximizing outcome as the binding discount condition represents an additional control variable to maximize upstream profits.

In addition, note that the fixed fee F^M_{A1} can also be written as $F^M_{A1} = \Pi_I - \Pi^o_R - \delta\{\pi_{A2}(c^I_{B2}) + \lambda\frac{1-\rho_1}{\rho_1}\frac{\partial\pi_{A2}}{\partial c_{B2}}q^I_{A1}\}$. Since $\Pi_I - \Pi^o_R$ has to be positive (otherwise A would not offer this contract) and since the last subtrahend is positive as well, it is not clear whether the fee is positive or negative (slotting fee). The sign and size of F^M_{A1} depends on the substitutability of the products, and of the learning parameter λ.

Proposition 2.3 (Learning-by-doing and market-share discounts).
The dominant supplier's profit-maximizing market-share discounts lead to the joint-profit maximizing result. The marginal cost level of the competitive fringe is therefore given by c^I_{B2}, which is larger than the level for two-part tariffs, and quantity discounts, c^T_{B2}.

Thus, the learning effect of the competitive fringe has an influence on the short-term contract decision of the dominant supplier: Compared to the benchmark case without learning-by-doing (where the dominant supplier chooses either a two-part tariff or a conditional discount scheme) market-share discounts are strictly more profitable for the dominant supplier, when learning occurs.

Corollary 2.1 (Profit-maximizing short-term contracts).
When the dominant supplier offers a single contract in each period, the dominant supplier will offer a binding market-share discount in period 1, combined with a two-part tariff, quantity discount or market-share discount in period 2.

This is because learning influences the decision of the downstream firm such that this monopolistic firm does not internalize industry profits. Instead, the downstream firm maximizes its long-run profits where it prefers to purchase more from the learning competitive fringe. A simple two-part tariff of the dominant supplier, defining a wholesale price and fixed fee, does not ensure enough instruments to control for the downstream quantity choice. Therefore, two-part tariffs cannot lead to maximum profits for the dominant supplier (given by the joint-profit maximizing outcome). Quantity discounts cannot improve the result as the additional discount condition characterizes an over-specification for the already present variables, and no additional control. Binding market-share discounts, however, solve for the maximum joint profit. They specify an additional control variable by introducing the market-share discount condition.

Accordingly, a competitive threat given by the learning effects of a rival provides an additional explanation for the granting of market-share discounts by a dominant supplier. The supplier uses market-share discounts to achieve the joint-profit maximizing outcome, which derives maximum upstream profits. It utilizes the learning effects of its competitor as these increase the profits of the downstream firm, and therefore the fixed fee which the dominant supplier will charge. The learning effects which are preferred by the dominant supplier, are characterized by c^I_{B2}. That is, the dominant supplier has no incentive to exclude the competitive fringe. Yet, as two-part tariffs and quantity discounts lead to larger learning effects ($c^{\mathrm{T}}_{B2} < c^I_{B2}$), the profitable contract choice of the dominant supplier restricts the learning effects to a certain extent.

2.3.3 Consumer surplus and welfare

Considering a general demand system, it is not possible to analyze the effects of conditional discounts on consumer surplus and social welfare. In case of quantity discounts or two-part tariffs, we have shown that the competitive fringe's first-period sales level is larger than in case of market-share discounts. Therefore, second-period sales for both products are also larger in case of quantity discounts. However, the effect on the dominant supplier's first-period sales is not clear. In case of quantity discounts, the dominant supplier's sales level is smaller than in case of market-share discounts. The extent to which q^{T}_{A1} is smaller and q^{T}_{B1} is larger than in case of market-share discounts cannot be calculated in the general case.

To obtain further results, we therefore consider the inverse demand system

$$P_A(q_{At}, q_{Bt}) = 1 - q_{At} - \gamma q_{Bt},$$
$$P_B(q_{At}, q_{Bt}) = 1 - q_{Bt} - \gamma q_{At}$$

for period $t = 1, 2$, where $\gamma \in (0, 1)$ is the degree of substitutability. In addition, we concentrate on $\delta = 1$. To ensure that all quantity levels are non-negative for the optimal, socially-efficient case, we assume that the degree of substitution is smaller than $\overline{\gamma} = \frac{1-c_{B1}}{1-c_A}$ if $c_A < c_{B1}$ (smaller than 1, if $c_{B1} < c_A$) and the learning parameter λ is positive and smaller than $\overline{\lambda} = 1 - \gamma \cdot \frac{1-c_{B1}}{1-c_A}$.

For this specification, we can show that the aggregate sales in both periods are smaller in case of market-share discounts and larger in case of quantity discounts. By introducing a quantity discount instead of a market-share discount, the decrease of q_{A1} is smaller than the increase in q_{B1}. Furthermore, final prices are smaller in case of quantity discounts and therefore consumer surplus is larger when market-share discounts are not feasible. The loss in producer surplus when using a quantity discount instead of market-share discount is smaller than the increase in consumer surplus.

Proposition 2.4 (Welfare)**.**
Given the specified inverse demand system, final prices are larger in case of market-share discounts compared to the alternative contractual terms. Consumer surplus as well as welfare are lower when the dominant supplier offers its profit-maximizing market-share discounts.

The proof is delegated to the appendix, section 2.6.2. Proposition 2.4 shows that a dominant supplier's market-share discounts can decrease consumer surplus and welfare. Even though industry profits increase and even though the competitive fringe is not excluded from the market, when the dominant supplier grants market-share discounts, aggregate sales and consumer surplus are lower. This is because in case of quantity discounts, the downstream firm's decision to purchase more of the fringe's good increases its sales more than it reduces the sales of the dominant supplier, compared to market-share discounts.

In antitrust law, market-share discounts and quantity discounts are both ranked as conditional discounts and are, as such, evaluated in a similar way. Their effects on competition however can differ in specific settings. When the fringe faces learning effects, market-share discounts are more profitable to the dominant supplier as they maximize industry profits. Yet, compared to two-part tariffs, market-share discounts limit the fringe's learning effects and may lead to lower consumer surplus as well as welfare. These discounts do not yield exclusion in the given context. In contrast, the dominant supplier achieves the industry-profit maximizing outcome by offering a market-share discount. That is, the dominant supplier achieves the outcome which is preferred whenever firms would cooperate. Nonetheless, market-share discounts dampen learning effects and hinder the growth of the competitor. On the contrary, quantity discounts do not show the same effects as market-share discounts. They do not lower consumer surplus, compared to simple two-part tariffs.

2.4 Robustness and extensions

In the previous section, we showed that the extent of a competitive fringe's learning effects is restricted by the dominant supplier's market-share discounts, compared to two-part tariffs or quantity discounts. In the following, we extend the model to consumption externalities and analyze the case where both the dominant supplier as well as the competitive fringe face learning effects. Then, we expand our assumptions regarding contract designs and downstream competition.

Consumption externalities

As learning-by-doing affects the pricing decision of upstream firms (i.e. the competitive fringe's wholesale price), it also influences the downstream quantity decision over time. As such, learning-by-doing represents one type of inter-temporal externalities which may change the market structure. A second type of inter-temporal externalities refer to consumption parameters (Sutton, 2001). In this case, demand, or respectively the willingness-to-pay increases depending on previous aggregate sales.

In this subsection, we consider the case where the competitive fringe faces externalities on consumption instead of learning-by-doing. We suppose that both the dominant supplier as well as the competitive fringe face constant marginal cost over time. In the present setting, however, the inverse demand structure changes: In the first period, we consider that final consumers' demand is characterized by $P_A(q_{A1}, q_{B1})$ and $P_B(q_{A1}, q_{B1})$. In the second period, demand for the fringe's good increases proportionally to the sold quantity in period 1, q_{B1}. For simplicity, we define the second-period inverse demand system as follows:

$$P_A(q_{A2}, q_{B2}),$$
$$P_B(q_{A2}, q_{B2}) + \kappa q_{B1}.$$

That is, the price-cost margin for the competitive fringe's good (according to the downstream firm's optimization problem) is given by $P_B(q_{A2}, q_{B2}) + \kappa q_{B1} - c_{B1}$. In case of learning-by-doing, this downstream mark-up was given by $P_B(q_{A2}, q_{B2}) - (c_{B1} - \lambda q_{B1})$. Hence, the downstream profit maximization only differs in the parameter κ, compared to the case with learning-by-doing, where λ was the key parameter.

That is, when the parameters κ and λ are equal, the downstream firm chooses the same quantities, with regard to the wholesale prices, as in case of learning-by-doing. Therefore, the optimal decision of the dominant supplier would also be similar to the previous setting and the same quantitative results would occur. In contrast, when κ differs from λ, however, the quantitative results differ. With regard to wholesale prices, the downstream firm purchases more from the fringe's good if κ is larger than λ, and vice versa. The dominant supplier's profit maximization reacts on this change in quantities, but derives the same qualitative results as before. Hence, even though consumption externalities might lead to different quantitative results, qualitative results are similar to the learning-by-doing setting.

A's learning-by-doing and consumption effects

In this subsection, we extend the model to allow for learning-by-doing by the dominant upstream firm. In that context, allowing for these effects by the dominant supplier does not change any of the qualitative results above. This is because the downstream firm internalizes only the learning effects of the competitive fringe, when the dominant supplier offers short-term contracts. The dominant supplier's cost (or demand parameter) does not affect the downstream firm's second-period profit, and the long-run outside option. Hence, the downstream firm anticipates the inter-temporal effects of B, but does not consider learning effects of the dominant supplier.

Thus, even when we suppose that both upstream firms face inter-temporal externalities, the result stays the same. An overview of this argument can be found in the appendix, section 2.6.3.

Long-term contracts

Long-run contracts define contract terms for multiple periods. These contracts are often said to have anticompetitive effects, see for example Faella (2008) and Hovenkamp (2006). In particular, contracts that are set for a long time period, respectively several (short-term) periods, can have a larger binding effect on buyers. This implies inter alia that competitors have fewer possibilities to conclude profitable contracts with buyers.

Suppose that the dominant supplier can set simple wholesale prices, and optionally discount conditions for both periods as well as a fixed fee in period one. In this case, a contract specifying $w_{A1} = w_{A2} = c_A$ and $F_{A1} = \Pi_I - \Pi_R^o$ yields the joint-profit maximizing outcome. The reason is that the downstream firm considers single-period industry payoffs in period two because the dominant supplier does not extract rents in the second-period from the downstream firm ($F_{A2} = 0$). In the first period, the downstream firm considers (and maximizes) long-run industry profits as long as wholesale prices equal marginal costs. With the fixed fee in period one, the dominant supplier can demand long-run industry profits minus the long-run outside option of the downstream firm.

Further contract types

In the analysis set out above, we concentrated on conditioned discounts, namely a contract conditioned on the own quantity level and a contract conditioning on relative purchases. The reason for this specification lies especially in the connection to the legal cases. However, the determined results can also be shown with further contract types. The joint-profit maximizing outcome can be achieved by contracts that relate to both quantity levels q_{A1} and q_{B1}. Examples are discounts that specify the aggregate quantity level of the downstream firm, revenue-sharing contracts that additionally specify the quantity level q_{A1}, or contracts with conditions that relate to (final) prices such as specific price relationship agreements.[15]

Contracts that only condition on the quantity level of the dominant supplier are not sufficient to reach maximum payoffs. The proof is sketched in the appendix,

[15]Regarding the definition of further contract types, see for example Cachon and Lariviere (2005), Feess and Wohlschlegel (2010), Scott-Morton (2012). Regarding price relationship agreements, see for example Aguzzoni et al. (2012).

section 2.6.3.

Downstream competition

In our model, we assumed that the downstream firm is a monopolist. In addition, the case with a single downstream firm also represents the situation where several downstream firms purchase the good of the dominant supplier, but downstream firms sell the goods in disjoint territories (exclusive territories). Furthermore, the demand for the goods, sold by multiple downstream firms, is independent of each other. Taking these assumptions into account, our model emphasizes market structures in which the downstream sector is characterized by firms with market power and where downstream firms have bargaining power vis-à-vis the upstream firms (so called buyer power). As market power of downstream firms as well as buyer power are mentioned in legal decisions (see section 1.1), our model assumptions build a simplified framework to analyze vertical agreements and inter-temporal externalities.

However, an additional question that may arise is whether the results hold in case of oligopolistic downstream competition. For the single-period model, Inderst and Shaffer (2010) show that market-share discounts are preferred by the dominant supplier. They achieve the industry-profit maximizing outcome and therefore hinder downstream competition.

In a two-period model with inter-temporal externalities, it can also be shown that market-share contracts, used in both periods, can solve for the industry-profit maximizing outcome. Thus, these contracts can hinder downstream competition and, at the same time, balance the quantity choice of the downstream firms to achieve the collusive outcome. An extension of Inderst and Shaffer (2010), regarding learning-by-doing, can be found in section 2.6.3.

Note that referring to the whole model, the assumption on the rent-shifting fixed fee is essential. Without a fixed fee, market-share discounts do not yield the determined results.

2.5 Conclusion

In this article, we examine the contract choice of a dominant upstream firm that faces a competitive threat caused by learning effects of a rival. We consider a two-period model in which the dominant supplier offers contracts to a single downstream firm. The contract structure is either a simple two-part tariff, a quantity discount or market-share discount.

We find that particularly in case of short-term contracts, the rival's learning effect has an impact on the contract choice of the dominant supplier. While all considered contract structures can derive the joint-profit maximizing outcome (which maximizes profits of the dominant supplier) when learning does not occur, retroactive quantity discounts and two-part tariffs cannot lead to the joint-profit maximizing outcome when inter-temporal externalities are considered. The reason for this result stems from the dynamic timing of the vertically structured model. The downstream firm which considers the learning effects of the upstream competitor chooses final quantities. The downstream firm supports learning as these effects increase its profits. The dominant supplier's quantity discounts do not provide enough instruments to control for the downstream quantity choice which considers only own effects.

Market-share discounts characterize the best contract choice for the dominant supplier, when inter-temporal externalities appear. This is because the discount condition characterizes an additional control variable for the dominant supplier. That is, binding market-share discounts, combined with a fixed fee, restrict the supporting effect of the downstream firm and lead to maximum profits for the dominant supplier.

Moreover, the profitable contract choice of the dominant supplier limits learning-by-doing, as contracts without discount schemes or with quantity discounts lead to larger learning effects. Similar results are achieved in case of consumption externalities.

This article contributes to the literature by analyzing discount schemes in a dynamic context where learning effects of rivals generate a growing competitive threat for a dominant supplier. By comparing different discount schemes, this paper presents a novel explanation for the use of market-share discounts and shows that especially these discounts can hinder competitors' efficiency gains and can, in specific settings, lower welfare.

2.6 Appendix

2.6.1 Learning-by-doing and optimal contract offers

For ease of comprehension of the proofs and calculations relating to the propositions, we firstly derive the optimal/profit-maximizing long-run outside option and joint profit.

Outside option:

The downstream firm's outside option is defined by purchasing only from the competitive fringe B. The optimal profit in the second period is given by

$$\pi^o_{R2}(c_{B2}) = \max_{q_{B2}} \, (P_B(0, q_{B2}) - c_{B2})q_{B2}.$$

The first-order condition characterizing the optimal quantity q^o_{B2} is given by

$$\frac{\partial P_B(0, q_{B2})}{\partial q_{B2}} q_{B2} + P_B(0, q_{B2}) - c_{B2} = 0. \tag{2.10}$$

The second order condition is negative, by definition, characterizing the unique maximum.

In the first period, the downstream firm chooses q^o_{B1} in case of purchasing only from B, given by

$$q^o_{B1} = \arg\max_{q_{B1}} \, (P_B(0, q_{B1}) - c_{B1})q_{B1} + \delta\pi^o_{R2}(c_{B2}).$$

The related profits are $\Pi^o_R = (P_B(0, q^o_{B1}) - c_{B1})q^o_{B1} + \delta\pi^o_{R2}(c^o_{B2})$ in the long run (where $c^o_{B2} = c_{B1} - \lambda q^o_{B1}$).

Joint profit:

Second period (solving by backwards induction):

$$\pi_{I2} = (P_A(q_{A2}, q_{B2}) - c_A)q_{A2} + (P_B(q_{A2}, q_{B2}) - c_{B2})q_{B2}.$$

Optimal second-period quantities $q^I_{A2}(c_{B2})$, $q^I_{B2}(c_{B2})$ are considered to be positive and given by

$$\frac{\partial P_A}{\partial q_{A2}} q_{A2} + \frac{\partial P_B}{\partial q_{A2}} q_{B2} + P_A(q_{A2}, q_{B2}) - c_A = 0, \tag{2.11}$$

$$\frac{\partial P_A}{\partial q_{B2}} q_{A2} + \frac{\partial P_B}{\partial q_{B2}} q_{B2} + P_B(q_{A2}, q_{B2}) - c_{B2} = 0. \tag{2.12}$$

As a two-part tariff, quantity discount, and market-share discount yield joint-profit maximization in a single period, these first-order conditions characterize the optimal second-period outcome in all these cases, leading to profits $\pi_{A2}(c_{B2}) = \pi_2^I(c_{B2}) - \pi_{R2}^o(c_{B2})$, where $\pi_2^I(c_{B2})$ represents maximum joint profit for the single period 2, and $\pi_{R2}^o(c_{B2})$ is the outside option for period 2.
First period:
Maximizing joint profit Π_I in the first period, we differentiate with respect to quantities q_{A1}, q_{B1}.

$$\Pi_I = (P_A(q_{A1}, q_{B1}) - c_A)q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1} + \delta\pi_2^I(c_{B2})$$

The first-order conditions which characterize the joint-profit maximizing quantities are given by (2.11), (2.12) and

$$\frac{\partial \Pi_I}{\partial q_{A1}} = \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A = 0, \tag{2.13}$$

$$\frac{\partial \Pi_I}{\partial q_{B1}} = \frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda \frac{\partial \pi_{I2}}{\partial c_{B2}} = 0. \tag{2.14}$$

Following assumption 2.1, the Hessian matrix of Π_I is negative definite. That is, the leading principal minors are $\frac{\partial^2 \Pi_I}{\partial q_{A1}^2} < 0$, and $\frac{\partial^2 \Pi_I}{\partial q_{A1}^2} \frac{\partial^2 \Pi_I}{\partial q_{B1}^2} - \frac{\partial^2 \Pi_I}{\partial q_{A1} \partial q_{B1}} \frac{\partial^2 \Pi_I}{\partial q_{B1} \partial q_{A1}} > 0$. Note that in this case: $\frac{\partial^2 \Pi_I}{\partial q_{B1}^2} < 0$, and $\frac{\partial^2 \Pi_I}{\partial q_{B1} \partial q_{A1}} = \frac{\partial^2 \Pi_I}{\partial q_{A1} \partial q_{B1}} < 0$, due to the assumptions on the inverse demand system.
Furthermore, it follows that $\frac{\partial^2 \Pi_I}{\partial q_{B1}^2} = \frac{\partial^2 P_A}{\partial q_{B1}^2} q_{A1} + \frac{\partial^2 P_B}{\partial q_{B1}^2} q_{B1} + 2\frac{\partial P_B}{\partial q_{B1}} + \delta\lambda^2 \frac{\partial^2 \pi_2^I}{\partial c_{B2}^2} < 0$, where

$$\frac{\partial^2 \pi_2^I}{\partial c_{B2}^2} = -\frac{\partial q_{B2}^I}{\partial c_{B2}} =$$

$$= -\frac{\frac{\partial^2 P_A}{\partial q_{A2}^2} q_{A2} + \frac{\partial^2 P_B}{\partial q_{A2}^2} q_{B2} + 2\frac{\partial P_A}{\partial q_{A2}}}{(\frac{\partial^2 P_A}{\partial q_{A2}^2} q_{A2} + \frac{\partial^2 P_B}{\partial q_{A2}^2} q_{B2} + 2\frac{\partial P_A}{\partial q_{A2}})(\frac{\partial^2 P_A}{\partial q_{B2}^2} q_{A2} + \frac{\partial^2 P_B}{\partial q_{B2}^2} q_{B2} + 2\frac{\partial P_B}{\partial q_{B2}}) - (\frac{\partial^2 P_A}{\partial q_{A2} \partial q_{B2}} q_{A2} + \frac{\partial^2 P_B}{\partial q_{A2} \partial q_{B2}} q_{B2} + \frac{\partial P_A}{\partial q_{B2}} + \frac{\partial P_B}{\partial q_{A2}})^2} > 0$$

(by using the implicit function theorem for the second-period first-order conditions).

Note that $q_{B2}^I(c_{B2}) < q_{B2}^o(c_{B2})$:
Per definition of the inverse demand structure:
$P_B(q_{A2}, q_{B2}) > P_B(0, q_{B2})$ for $q_{A2} > 0$,
and $\frac{\partial P_A}{\partial q_{B2}} < 0$, $\frac{\partial P_B(q_{A2}, q_{B2})}{\partial q_{B2}} \leq \frac{\partial P_B(0, q_{B2})}{\partial q_{B2}}$.
Hence, for all $q_{A2} > 0$, the left-hand side (LHS) of equation (2.10) is larger than the LHS of equation (2.12). Thus, the quantity level $q_{B2}^o(c_{B2})$ is larger than $q_{B2}^I(c_{B2})$

(for the optimal level of $q^I_{A2}(c_{B2}) > 0$).

Proof of lemma 2.1:
In this case, the dominant upstream firm offers a two-part tariff in both periods. We solve for the profit-maximizing contract by backwards induction. In the second period, (2.11), (2.12) characterize the optimal outcome, and lead to profits $\pi_{A2}(c_{B2})$ for A, and $\pi^o_{R2}(c_{B2})$ for R.

Downstream:
In the first period, the downstream firm maximizes profits

$$\Pi_R(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - w_{A1})q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1} - F_{A1} + \delta\pi^o_{R2}(c_{B2})$$

with respect to both quantities q_{A1}, q_{B1}. The following first-order conditions characterize the optimal choice $q_{A1}(w_{A1})$, $q_{B1}(w_{A1})$ in dependance of the wholesale price:

$$\frac{\partial \Pi_R}{\partial q_{A1}} = \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - w_{A1} = 0 \tag{2.15}$$

$$\frac{\partial \Pi_R}{\partial q_{B1}} = \frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda \frac{\partial \pi^o_{R2}}{\partial c_{B2}} = 0 \tag{2.16}$$

Considering that the Hessian matrix of Π_R is negative definite ensures that $q_{A1}(w_{A1})$ and $q_{B1}(w_{A1})$ represent the maximum of Π_R.

Note that $\frac{\partial q_{A1}}{\partial w_{A1}} < 0$, $\frac{\partial q_{B1}}{\partial w_{A1}} > 0$:
By differentiating (2.15), (2.16) with respect to w_{A1} and regarding the second-order conditions (implicit function theorem), we get

$\frac{\partial q_{A1}}{\partial w_{A1}} = \frac{1}{a}\left(\frac{\partial^2 P_A}{\partial q^2_{B1}} q_{A1} + \frac{\partial^2 P_B}{\partial q^2_{B1}} q_{B1} + 2\frac{\partial P_B}{\partial q_{B1}} + \delta\lambda^2 \frac{\partial^2 \pi^o_{R2}}{\partial c^2_{B2}}\right) < 0$,

$\frac{\partial q_{B1}}{\partial w_{A1}} = -\frac{1}{a}\left(\frac{\partial^2 P_A}{\partial q_{B1}\partial q_{A1}} q_{A1} + \frac{\partial^2 P_B}{\partial q_{B1}\partial q_{A1}} q_{B1} + \frac{\partial P_B}{\partial q_{A1}} + \frac{\partial P_A}{\partial q_{B1}}\right) > 0$

where a is the (second) leading principal minor of the Hessian matrix of Π_R: $a = a_{11}a_{22} - a_{12}a_{21} > 0$, with

$a_{11} = \left(\frac{\partial^2 P_A}{\partial q^2_{A1}} q_{A1} + \frac{\partial^2 P_B}{\partial q^2_{A1}} q_{B1} + 2\frac{\partial P_A}{\partial q_{A1}}\right)$

$a_{22} = \left(\frac{\partial^2 P_A}{\partial q^2_{B1}} q_{A1} + \frac{\partial^2 P_B}{\partial q^2_{B1}} q_{B1} + 2\frac{\partial P_B}{\partial q_{B1}} + \delta\lambda^2 \frac{\partial^2 \pi^o_{R2}}{\partial c^2_{B2}}\right)$

$a_{12} = a_{21} = \left(\frac{\partial^2 P_A}{\partial q_{B1}\partial q_{A1}} q_{A1} + \frac{\partial^2 P_B}{\partial q_{B1}\partial q_{A1}} q_{B1} + \frac{\partial P_B}{\partial q_{A1}} + \frac{\partial P_A}{\partial q_{B1}}\right)$. Moreover,

$$\frac{\frac{\partial q_{B1}}{\partial w_{A1}}}{\frac{\partial q_{A1}}{\partial w_{A1}}} = -\frac{a_{12}}{a_{22}} = -\frac{\frac{\partial^2 P_A}{\partial q_{B1}\partial q_{A1}} q_{A1} + \frac{\partial^2 P_B}{\partial q_{B1}\partial q_{A1}} q_{B1} + \frac{\partial P_B}{\partial q_{A1}} + \frac{\partial P_A}{\partial q_{B1}}}{\frac{\partial^2 P_A}{\partial q^2_{B1}} q_{A1} + \frac{\partial^2 P_B}{\partial q^2_{B1}} q_{B1} + 2\frac{\partial P_B}{\partial q_{B1}} + \delta\lambda^2 \frac{\partial^2 \pi^o_{R2}}{\partial c^2_{B2}}} < 0 \tag{2.17}$$

where the denominator is negative, by definition. (This is due to the negative definite Hessian matrix.)

Upstream:

A's profits are given by

$$\Pi_A = q_{A1}(w_{A1} - c_A) + F_{A1} + \delta(\pi_2^I(c_{B2}) - \pi_{R2}^o(c_{B2})).$$

We optimize with respect to w_{A1}, F_{A1} and subject to the participation constraint

$$\Pi_R(q_{A1}(w_{A1}), q_{B1}(w_{A1})) - F_{A1} \geq \Pi_R^o.$$

The participation constraint is binding, which leads to the following simplified optimization problem:

$$\max_{w_{A1}}(P_A(q_{A1}(w_{A1}), q_{B1}(w_{A1})) - c_A)q_{A1}(w_{A1}) \\ + (P_B(q_{A1}(w_{A1}), q_{B1}(w_{A1})) - c_{B1})q_{B1}(w_{A1}) + \delta\pi_2^I(c_{B2}) - \Pi_R^o.$$

The optimization depends on w_{A1}, in the first instance. The difference between the joint profit function and the objective function of A's optimization problem is given by the quantities q_{A1}, q_{B1} which depend on w_{A1}.

Using (2.15), (2.16), and differentiating the simplified objective function, we get the optimal wholesale price w_{A1}^{T} by

$$(w_{A1}^{\mathrm{T}} - c_A)\frac{\partial q_{A1}}{\partial w_{A1}} - \delta\lambda\frac{\partial \pi_{A2}}{\partial c_{B2}}\frac{\partial q_{B1}}{\partial w_{A1}} = 0. \tag{2.18}$$

Since A's second-period profit increases with respect to c_{B2}, for all $c_{B2} \in [0, c_{B1}]$, the optimal wholesale price from A's point of view is smaller than marginal cost.[16]

Moreover, inserting the optimal wholesale price in (2.15), (2.16) achieves the optimal outcome in case of two-part tariffs. The profit maximizing first-period two-part tariff is given by $(w_{A1}^{\mathrm{T}}, F_{A1}^{\mathrm{T}})$ where (2.18) characterizes the wholesale price, and $F_{A1}^{\mathrm{T}} = \Pi_R(q_{A1}^{\mathrm{T}}, q_{B1}^{\mathrm{T}}) - \Pi_R^o$ (with w_{A1}^{T}).

Proof of proposition 2.1:

We show that $q_{B1}^I < q_{B1}^{\mathrm{T}}$ for $\lambda > 0$.

First, we compare the equation system

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1}, q_{B1}) - c_A = 0, \tag{2.13}$$

$$\frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda\frac{\partial \pi_{I2}}{\partial c_{B2}} = 0, \tag{2.14}$$

[16] This wholesale price characterizes the maximum because the second order condition is negative.

with the varied system

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A + \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}}|_{c_{B2}^{\mathrm{T}}} = 0, \tag{2.13'}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda \frac{\partial \pi_2^I}{\partial c_{B2}} + \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}}|_{c_{B2}^{\mathrm{T}}} = 0. \tag{2.14'}$$

Here, the varied system represents the first-order conditions of the function $\Pi_I(q_{A1}, q_{B1}) + \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}}|_{c_{B2}^{\mathrm{T}}} q_{A1} + \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}}|_{c_{B2}^{\mathrm{T}}} q_{B1} + constant$, where *constant* as well as $\frac{\partial \pi_{A2}}{\partial c_{B2}}|_{c_{B2}^{\mathrm{T}}}$ are constant, real values. Therefore, (2.13') and (2.14') characterize the maximum $(q_{A1}^{var}, q_{B1}^{var})$ of the new, varied objective function. As the latter two summands of the new objective function move the maximum outside (away from the origin), compared to the joint-profit maximum, the location of the maximum (of the varied function) is characterized by $q_{A1}^{var} > q_{A1}^{I}$ and $q_{B1}^{var} > q_{B1}^{I}$.

Second, we compare the varied system with

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}}|_{c_{B2}^{\mathrm{T}}} \left(\frac{\partial q_{B1}/\partial w_{A1}}{\partial q_{A1}/\partial w_{A1}}\right)|_{c_{B2}^{\mathrm{T}}} = 0, \tag{2.19}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_{B1} - \delta\lambda \frac{\partial \pi_{R2}^o}{\partial c_{B2}} = 0. \tag{2.20}$$

This system characterizes the optimal quantity levels q_{A1}^{T} and q_{B1}^{T} in case of a two-part tariff, while the varied system characterizes the optimal levels q_{A1}^{var}, q_{B1}^{var} of the varied objective function. We can proof by contradiction that the systems do not lead to the same outcome. In particular, assume that $q_{A1}^{\mathrm{T}} = q_{A1}^{var}$ and $q_{B1}^{\mathrm{T}} = q_{B1}^{var}$.

The multiplier $-\frac{\partial q_{B1}/\partial w_{A1}}{\partial q_{A1}/\partial w_{A1}}$ is positive and never zero. In addition, it is considered that the multiplier is smaller than 1 (as is the case whenever $|\frac{\partial^2 P_A}{\partial q_{B1}\partial q_{A1}} q_{A1} + \frac{\partial^2 P_B}{\partial q_{B1}\partial q_{A1}} q_{B1} + \frac{\partial P_B}{\partial q_{A1}} + \frac{\partial P_A}{\partial q_{B1}}| < |\frac{\partial^2 P_A}{\partial q_{B1}^2} q_{A1} + \frac{\partial^2 P_B}{\partial q_{B1}^2} q_{B1} + 2\frac{\partial P_B}{\partial q_{B1}} + \delta\lambda^2 \frac{\partial^2 \pi_{R2}^o}{\partial c_{B2}^2}|$). Therefore, the outcomes cannot be equal. Instead, the optimal level q_{A1}^{T} must be smaller than q_{A1}^{var}, and q_{B1}^{T} larger than q_{B1}^{var}.

Altogether, $q_{B1}^{\mathrm{T}} > q_{B1}^{var} > q_{B1}^{I}$. (As $q_{A1}^{\mathrm{T}} < q_{A1}^{var}$ and $q_{A1}^{I} < q_{A1}^{var}$ there is no definite order for q_{A1}^{I} and q_{A1}^{T}.)

Proof of lemma 2.2, and proposition 2.2:

Solving by backwards induction, second-period profits are given by $\pi_{A2}(c_{B2})$ for A, and $\pi_{R2}^o(c_{B2})$ for R.

Downstream:

In the first period, the downstream firm R decides to accept A's contract, and discount condition, or rejects the offer, maximizing long-run profits

$$\Pi_R(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - w_{A1})q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1} + \delta\pi^o_{R2}(c_{B2})$$

where $c_{B2} = c_{B1} - \lambda q_{B1}$. As R is the only downstream firm, A will force R to accept the discount condition. Hence, the un-discounted wholesale price is as large as necessary to hinder R from accepting this un-discounted offer. When R rejects the offer, it earns Π^o_R. If R accepts the discount, its optimization problem is

$$\max_{q_{A1}, q_{B1}} \Pi_R(q_{A1}, q_{B1})$$
$$s.t. \quad q_{A1} \geq q^*_{A1}$$

where $w_{A1} = w_{Q1}$. In case of the side condition being non-binding, the first order conditions (2.15), (2.16) characterize the optimal quantity choice, leading to the same results as two-part tariffs. Therefore, we concentrate on the binding case, where $q_{A1} = q^*_{A1}$ and R maximizes only with respect to q_{B1}. This optimal downstream choice is now given by (2.16), where $q_{B1}(q^*_{A1})$ depends on A's first-period quantity, but does not depend on the wholesale price w_{Q1}. R accepts the discount when the following participation constraint is fulfilled:

$$\begin{aligned}(P_A(q^*_{A1}, q_{B1}(q^*_{A1})) - w_{Q1})q^*_{A1} + (P_B(q^*_{A1}, q_{B1}(q^*_{A1})) - c_{B1})q_{B1}(q^*_{A1}) - F^{Q}_{A1} \\ + \delta\pi^o_{R2}(c_{B2}) \geq \Pi^o_R. \qquad (2.21)\end{aligned}$$

Upstream:
A will maximize profits Π_A with respect to q^*_{A1}, w_{Q1} and F^{Q}_{A1}, subject to (2.21). Following the Kuhn-Tucker conditions, (2.21) is binding. Thus, the optimization problem can be simplified to

$$\max_{q^*_{A1}} \quad (P_A(q^*_{A1}, q_{B1}(q^*_{A1})) - c_A)q^*_{A1} + (P_B(q^*_{A1}, q_{B1}(q^*_{A1})) - c_{B1})q_{B1}(q^*_{A1}) + \delta\pi^I_2(c_{B2}) - \Pi^o_R.$$

Note that the (simplified) optimization problem does not depend on w_{Q1}. The wholesale price as well as the fixed fee serve to reach R's acceptance. They can be substituted with respect to
$F^{Q}_{A1} = (P_A(q^*_{A1}, q_{B1}(q^*_{A1})) - w_{Q1})q^*_{A1} + (P_B(q^*_{A1}, q_{B1}(q^*_{A1})) - c_{B1})q_{B1}(q^*_{A1}) + \delta\pi^o_{R2}(c_{B2}) - \Pi^o_R.$

Differentiating the simplified optimization problem with respect to q^*_{A1}, we get

$$\frac{\partial P_A}{\partial q^*_{A1}} q^*_{A1} + \frac{\partial P_B}{\partial q^*_{A1}} q_{B1}(q^*_{A1}) + P_A(q^*_{A1}, q_{B1}(q^*_{A1})) - c_A - \delta\lambda \frac{\partial \pi_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}}{\partial q^*_{A1}}$$
$$+ \underbrace{\left(\frac{\partial P_A}{\partial q_{B1}} q^*_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1}(q^*_{A1}) + P_B(q^*_{A1}, q_{B1}(q^*_{A1})) - c_{B1} - \delta\lambda \frac{\partial \pi^o_{R2}}{\partial c_{B2}} \right)}_{=0, \text{see } (2.16)} \frac{\partial q_{B1}}{\partial q^*_{A1}} = 0 \tag{2.22}$$

Note that $\frac{\partial q_{B1}}{\partial q^*_{A1}} = \frac{\partial q_{B1}/\partial w_{A1}}{\partial q_{A1}/\partial w_{A1}}$:
By using the implicit function theorem on (2.16), we get the derivation of q_{B1} with respect to q^*_{A1}:

$$\frac{\partial q_{B1}}{\partial q^*_{A1}} = - \frac{\frac{\partial^2 P_A}{\partial q_{B1} \partial q_{A1}} q^*_{A1} + \frac{\partial^2 P_B}{\partial q_{B1} \partial q_{A1}} q_{B1} + \frac{\partial P_B}{\partial q_{A1}} + \frac{\partial P_A}{\partial q_{B1}}}{\frac{\partial^2 P_A}{\partial q^2_{B1}} q_{A1} + \frac{\partial^2 P_B}{\partial q^2_{B1}} q_{B1} + 2\frac{\partial P_B}{\partial q_{B1}} + \delta\lambda^2 \frac{\partial^2 \pi^o_{R2}}{\partial c^2_{B2}}}$$

The RHS of this equation equals the ratio between $\frac{\partial q_{B1}}{\partial w_{A1}}$ and $\frac{\partial q_{A1}}{\partial w_{A1}}$, also given by the implicit function theorem on (2.15), (2.16).

As q_{B1} is characterized by (2.20) (similar to the case of two-part tariffs) and as second-period payoffs only depend on q_{B1}, binding as well as non-binding quantity discounts lead to the same outcome as two-part tariffs. That is, learning-by-doing in case of quantity discounts is also larger than in case of maximum industry profits.

Proof of lemma 2.3:
Solving by backwards induction, second-period profits are given by $\pi_{A2}(c_{B2})$ for A, and $\pi^o_{R2}(c_{B2})$ for R, again.

Downstream:
In the first period, the downstream firm has the choice to accept A's contract, and market-share discount condition, or reject the offer. Rejecting implies profits Π^o_R for R. Accepting the contract is unprofitable in case of not-fulfilling the discount condition (for the same reasons as in case of quantity discounts). Fulfilling the discount condition, the downstream firm R maximizes profits $\Pi_R(q_{A1}, \frac{1-\rho_1}{\rho_1} q_{A1})$ with respect to q_{A1} and ρ_1 (where $\rho_1 = q_{A1}/(q_{A1}+q_{B1})$), and subject to $\rho_1 \geq \rho^*_1$. Note that the profit function is concave in q_{A1} and ρ_1, given by the concavity of $\Pi_R(q_{A1}, q_{B1})$ (in both quantities). As a non-binding discount condition leads to the same result as two-part tariffs, we are interested in the binding discount condition. The first-order

condition, characterizing $q_{A1}(w_{M1}, \rho_1^*)$, is

$$\frac{\partial \Pi_R}{\partial q_{A1}} = \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} \frac{1-\rho_1}{\rho_1} q_{A1} + P_A(q_{A1}, \frac{1-\rho_1}{\rho_1} q_{A1}) - w_{M1}$$
$$+ \frac{1-\rho_1}{\rho_1} \left(\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho_1}{\rho_1} q_{A1} + P_B(q_{A1}, \frac{1-\rho_1}{\rho_1} q_{A1}) - c_{B1} - \delta\lambda \frac{\partial \pi^o_{R2}}{\partial c_{B2}} \right) = 0. \tag{2.23}$$

Upstream:

A maximizes profits with respect to w_{M1}, ρ_1^* and F_{A1} subject to the participation constraint, which is now given by

$$(P_A \left(q_{A1}(w_{M1}, \rho_1^*), \frac{1-\rho_1^*}{\rho_1^*} q_{A1}(w_{M1}, \rho_1^*) \right) - w_{A1}) q_{A1}(w_{M1}, \rho_1^*)$$
$$+ (P_B \left(q_{A1}(w_{M1}, \rho_1^*), \frac{1-\rho_1^*}{\rho_1^*} q_{A1}(w_{M1}, \rho_1^*) \right) - c_{B1}) \frac{1-\rho_1^*}{\rho_1^*} q_{A1}(w_{M1}, \rho_1^*) + \delta \pi^o_{R2}(c_{B2}) - F^{M}_{A1} \geq \Pi^o_R$$

Here as well, the fixed fee serves to shift rents upwards. The participation constraint is hence binding. In contrast to the quantity discount however, the discounted wholesale price w_{M1} as well as the share ρ_1^* will be used by the dominant firm to maximize R's profits. The simplified optimization problem can be written as

$$\max_{w_{M1}, \rho_1^*} \left(P_A(q_{A1}(w_{M1}, \rho_1^*), \frac{1-\rho_1^*}{\rho_1^*} q_{A1}(w_{M1}, \rho_1^*)) - c_A \right) q_{A1}(w_{M1}, \rho_1^*)$$
$$+ \left(P_B(q_{A1}(w_{M1}, \rho_1^*), \frac{1-\rho_1^*}{\rho_1^*} q_{A1}(w_{M1}, \rho_1^*)) - c_{B1} \right) \frac{1-\rho_1^*}{\rho_1^*} q_{A1}(w_{M1}, \rho_1^*)$$
$$+ \delta \pi^I_2(c_{B2}) - \Pi^o_R$$

The first order conditions are given by

$$\frac{\partial \cdot}{\partial w_{M1}} = \left\{ \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} \frac{1-\rho_1^*}{\rho_1^*} q_{A1} + P_A(q_{A1}, \frac{1-\rho_1^*}{\rho_1^*} q_{A1}) - c_A \right.$$
$$\left. + \frac{1-\rho_1^*}{\rho_1^*} \left(\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho_1^*}{\rho_1^*} q_{A1} + P_B(q_{A1}, \frac{1-\rho_1^*}{\rho_1^*} q_{A1}) - c_{B1} - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} \right) \right\} \frac{\partial q_{A1}}{\partial w_{M1}} = 0$$

$$\frac{\partial \cdot}{\partial \rho_1^*} = \left\{ \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} \frac{1-\rho_1^*}{\rho_1^*} q_{A1} + P_A(q_{A1}, \frac{1-\rho_1^*}{\rho_1^*} q_{A1}) - c_A \right.$$
$$\left. + \frac{1-\rho_1^*}{\rho_1^*} \left(\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho_1^*}{\rho_1^*} q_{A1} + P_B(q_{A1}, \frac{1-\rho_1^*}{\rho_1^*} q_{A1}) - c_{B1} - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} \right) \right\} \frac{\partial q_{A1}}{\partial \rho_1^*}$$
$$- \frac{q_{A1}}{(\rho_1^*)^2} \left\{ \frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho_1^*}{\rho_1^*} q_{A1} + P_B(q_{A1}, \frac{1-\rho_1^*}{\rho_1^*} q_{A1}) - c_{B1} - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} \right\} = 0$$

where $q_{A1} = q_{A1}(w_{M1}, \rho_1^*)$.

Inserting (2.22) into the first-order conditions of A, we get

$$w_{M1} - c_A - \delta\lambda \frac{1-\rho_1^*}{\rho_1^*} \frac{\partial \pi_{A2}}{\partial c_{B2}} = 0 \tag{2.24}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho_1^*}{\rho_1^*} q_{A1} + P_B(q_{A1}, \frac{1-\rho_1^*}{\rho_1^*} q_{A1}) - c_{B1} - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} = 0 \tag{2.25}$$

Moreover, the outcome equals the joint-profit maximizing outcome, see (2.13) and (2.14). The optimal long-run profit of the dominant supplier is given by maximum industry profits minus R's outside option: $\Pi_I - \Pi_R^o$.

Following (2.24), the wholesale price is larger than marginal cost. In regard to (2.13) and (2.14), the optimal share ρ_1^* is equal to the joint-profit maximizing one. As ρ_1^* is larger than the share that R would prefer, the downstream firm would accept this market-share discount and would not have any ambitions to purchase a larger share of A's good. Altogether, the downstream firm will accept the market-share discount that yields maximum profits for A.

2.6.2 Welfare

The inverse linear demand system introduced in section 2.3.3 is implicated by the utility function

$$U(q_{At}, q_{Bt}) = q_{At} + q_{Bt} - \frac{q_{At}^2 + q_{Bt}^2 + 2\gamma q_{At} q_{Bt}}{2}.$$

The aggregate social welfare function, depending on the sales levels q_{Jt}, $J = A, R$ and $t = 1, 2$, is given by the sum of consumer surplus and producer surplus for both periods. Consumer surplus is given by

$$CS_t(q_{At}, q_{Bt}) = U(q_{At}, q_{Bt}) - P_A(q_{At}, q_{Bt})q_{At} - P_B(q_{At}, q_{Bt})q_{Bt}$$

and producer surplus is given by the profits of the dominant supplier and the downstream firm.

The socially efficient outcome is characterized by

$q_{A1}^W = \frac{(1-\lambda)(1-c_A)-\gamma(1-c_{B1})}{1-\gamma^2-\lambda}$,

$q_{B1}^W = \frac{1-c_{B1}-\gamma(1-c_A)}{1-\gamma^2-\lambda}$,

$q_{A2}^W = q_{A1}^W$,

$q_{B2}^W = q_{B1}^W$.

To allow for all parameter constellations in which the competitive fringe is active (in a socially optimal case), we assume that

$(1-\lambda)(1-c_A) - \gamma(1-c_{B1}) \geq 0$, $1 - c_{B1} - \gamma(1-c_A) \geq 0$, and $1 - \gamma^2 - \lambda > 0$.

These conditions are equivalent to considering

$0 < \gamma \leq \frac{1-c_{B1}}{1-c_A}$ if $c_A < c_{B1}$, or $0 < \gamma < 1$ else, and $0 < \lambda < 1 - \gamma \cdot \frac{1-c_{B1}}{1-c_A}$.

Using the first-order conditions characterized in section 2.3.2, we get the following outcomes for the analyzed cases:

Quantity discount and two-part tariff

In case of two-part tariffs and quantity discounts, the outcome is the same and given by $q^{\mathrm{T}}_{A1} = \frac{(2+\lambda)\{(2-\lambda)(1-c_A)-2\gamma(1-c_{B1})\}\cdot[(4-\lambda^2)(1-\gamma^2)+2\lambda]}{2\{(4-\lambda^2)^2+8\gamma^4(2-\lambda^2)-\gamma^2(32-12\lambda^2+\lambda^4)\}}$
$q^{\mathrm{T}}_{B1} = \frac{(4\gamma^4\lambda+(1-\gamma^2)(2-\lambda)(2+\lambda)^2)(1-c_{B1})-2\gamma(4-\lambda^2+\gamma^2(4-2\lambda-\lambda^2))(1-c_A)}{(4-\lambda^2)^2+8\gamma^4(2-\lambda^2)-\gamma^2(32-12\lambda^2+\lambda^4)}$
$q^{\mathrm{T}}_{A2} = \frac{1-c_A-\gamma(1-c^{\mathrm{T}}_{B2})}{4(1-\gamma^2)}$
$q^{\mathrm{T}}_{B2} = \frac{(2-\gamma^2)(1-c^{\mathrm{T}}_{B2})-\gamma(1-c_A)}{4(1-\gamma^2)}$

Market-share discount and joint profit maximum

In case of market-share discounts, the outcome is the same as in case of maximum industry profits. Hence, in both cases we get
$q^I_{A1} = \frac{(2-\lambda)(1-c_A)-2\gamma(1-c_{B1})}{2(2(1-\gamma^2)-\lambda)}$
$q^I_{B1} = \frac{1-c_{B1}-\gamma(1-c_A)}{2(1-\gamma^2)-\lambda}$
$q^I_{A2} = q^I_{A1}$
$q^I_{B2} = q^I_{B1}$

As already shown in section 2.3.2, $q^{\mathrm{T}}_{B1} > q^I_{B1}$. Furthermore, this inequality implies that $c^{\mathrm{T}}_{B2} < c^I_{B2}$ and therefore $q^{\mathrm{T}}_{A2} + q^{\mathrm{T}}_{B2} > q^I_{A2} + q^I_{B2}$. For the dominant supplier's first-period sales, we get $q^I_{A1} > q^{\mathrm{T}}_{A1}$, and $q^I_{A1} + q^I_{B1} < q^{\mathrm{T}}_{A1} + q^{\mathrm{T}}_{B1}$.

Hence, consumer surplus is larger in case of two-part tariffs than in case of market-share discounts, when learning occurs. In addition, welfare is also larger in case of two-part tariffs due to the quantity levels.

2.6.3 Robustness

A's learning-by-doing and consumption effects

Here, we suppose that the dominant upstream supplier's marginal cost decreases proportionally to the quantity sold in period 1:

$$c_{A2} = \max\{0, c_A - \lambda_A q_{A1}\}.$$

$\lambda_A > 0$ denotes A's learning parameter which does not need to equal the learning parameter of the competitive fringe. That is, we allow for different speeds of progress. The competitive fringe might for example face a larger learning parameter and might therefore present a potential threat for the dominant firm. To guarantee that the learning-by-doing progress is continuing, assume $\lambda_A \leq \frac{c_A}{q^I_{A1}}$, for q^I_{A1} being the quantity sold in case of maximum joint profits.

In this context, maximum industry profits depend on learning-by-doing of all upstream firms. Long-run joint profit is characterized by

$$\Pi_I = \pi_{I1}(q_{A1}, q_{B1}) + \delta \pi^I_2(c_{A2}, c_{B2})$$

where $\pi_{I1}(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - c_A)q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1}$ and second-period maximum industry profit depends on both c_{B2} and c_{A2}. Thus, the optimal quantities q^I_{A1}, q^I_{B1} in period 1 depend on the degrees of learning λ, λ_A.

In case of short-run contracts, we first observe the downstream firm's decision. In period 2, the downstream firm earns the outside option $\pi_{R2}(c_{B2})$, independent of conditional discounts. With respect to period 1, however the firm maximizes long-run profits $\Pi_R(q_{A1}, q_{B1})$ and accepts the dominant firm's contract offer only if profits at least equal the long-run outside option Π^o_R. As before, the single-period and long-run outside options depend on q_{B1}, respectively only on the fringe's learning effects. Maximizing profits, the downstream firm does not internalize the dominant firm's learning effects. Again, market-share contracts are preferred by the dominant supplier and lead to the joint-payoff maximizing outcome.

Proof by contradiction, that own-quantity contracts do not achieve q^I_{A1}, q^I_{B1}

Suppose that a contract $T(q_{A1})$ that only depends on q_{A1} achieves the joint-profit maximizing outcome q^I_{A1}, q^I_{B1} which is represented by the first-order conditions (2.13), (2.14).

That is, $T(q_{A1})$ is such that the maximization problem of the downstream firm

$$\max_{q_{A1}, q_{B1}} \tilde{\Pi}_R(q_{A1}, q_{B1}) = P_A(q_{A1}, q_{B1})q_{A1} + (P_B(q_{A1}, q_{B1}) - c_{B1})q_{B1} - T(q_{A1}) + \delta \pi^o_{R2}(c_{B2})$$

leads to q^I_{A1}, q^I_{B1}.

That is, the partial derivatives of $\tilde{\Pi}_R(q_{A1}, q_{B1})$ must be zero for q^I_{A1}, q^I_{B1}. Especially for the partial derivative $\frac{\partial \tilde{\Pi}_R}{\partial q_{B1}}$ this cannot hold, because $\frac{\partial \pi^o_{R2}}{\partial c_{B2}} \neq \frac{\partial \pi^I_2}{\partial c_{B2}}$.

Only if the contract can also be conditioned on q_{B1} the joint-profit maximizing outcome can be achieved.

Downstream competition

Suppose there are two downstream firms, n and m. Each downstream firm can resell the goods of A and B. The quantities sold by $l = n, m$ in period $t = 1, 2$ are denoted by q_{Jlt}, with $J = A, B$. The demand for good J sold by l in period t is represented by

$$P_{Jl}(q_{Jlt}, q_{Klt}, q_{Jot}, q_{Kot}) = 1 - q_{Jlt} - \gamma q_{Klt} - \eta q_{Jot} - \eta\gamma q_{Kot}$$

We solve the model by backwards induction and start with period 2. Following Inderst and Shaffer (2010), the industry-profit maximizing outcome q^I_{An2}, q^I_{Am2}, q^I_{Bn2}, q^I_{Bm2} is the optimal outcome, achieved by market-share discounts. The second period payoffs of the downstream firms are $\pi_{l2} = \pi^o_{l2}$, where π^o_{l2} is the outside option of $l = n, m$ if it does not purchase A's good. The second-period payoff of supplier A is $\pi_{A2} = \pi^I_2 - \pi_{n2} - \pi_{m2}$ with π^I_2 being the maximum second-period industry profit. All these profits depend on marginal costs c_{B2}.

In period one, all firms consider their second-period payoffs.

For comparison, we first note the *industry profit maximizing outcome:*
q^I_{Al1}, q^I_{Bl1} are characterized by

$$\begin{aligned}
&\frac{\partial P_{Al}}{\partial q_{Al1}} q_{Al1} + \frac{\partial P_{Bl}}{\partial q_{Al1}} q_{Bl1} + \frac{\partial P_{Ao}}{\partial q_{Al1}} q_{Ao1} + \frac{\partial P_{Bo}}{\partial q_{Al1}} q_{Bo1} + P_{Al} - c_A = 0,\\
&\frac{\partial P_{Al}}{\partial q_{Bl1}} q_{Al1} + \frac{\partial P_{Bl}}{\partial q_{Bl1}} q_{Bl1} + \frac{\partial P_{Ao}}{\partial q_{Bl1}} q_{Ao1} + \frac{\partial P_{Bo}}{\partial q_{Bl1}} q_{Bo1} + P_{Bl} - c_{B1} - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} = 0.
\end{aligned}$$

If the dominant supplier offers market-share contracts to both downstream firms, the optimization problem of $l = n, m$ is given by

$$\begin{aligned}
&\max_{q_{Al1}, q_{Bl1}} \; (P_{Al} - w_{Al1}) q_{Al1} + (P_{Bl} - c_{B1}) q_{Bl1} - F_{Al1} + \delta \pi_{l2}(c_{B2})\\
&\text{s.t.} \quad \rho_{l1} = \frac{q_{Al1}}{q_{Al1} + q_{Bl1}} \geq \rho^*_{l1}.
\end{aligned}$$

The market share condition will be binding. Therefore, the quantity choice of the downstream firm $l = n, m$ is characterized by

$$\begin{aligned}
&\frac{\partial P_{Al}}{\partial q_{Al1}} q_{Al1} + \frac{\partial P_{Bl}}{\partial q_{Al1}} \frac{1 - \rho_{l1}}{\rho_{l1}} q_{Al1} + P_{Al} - c_A\\
&+ \frac{1 - \rho_{l1}}{\rho_{l1}} \left(\frac{\partial P_{Al}}{\partial q_{Bl1}} q_{Al1} + \frac{\partial P_{Bl}}{\partial q_{Bl1}} \frac{1 - \rho_{l1}}{\rho_{l1}} q_{Al1} + P_{Bl} - c_{B1} - \delta\lambda \frac{\partial \pi_{l2}}{\partial c_{B2}} \right) = 0.
\end{aligned}$$

Setting $\rho_{l1} = \frac{q^I_{Al1}}{q^I_{Al1}+q^I_{Bl1}}$ and

$$\begin{aligned} w_{Al1} = & c_A - \frac{\partial P_{Ao}}{\partial q_{Al1}} q_{Ao1} - \frac{\partial P_{Bo}}{\partial q_{Al1}} q_{Bo1} \\ & - \frac{1-\rho_{l1}}{\rho_{l1}} \frac{\partial P_{Ao}}{\partial q_{Bl1}} q_{Ao1} - \frac{1-\rho_{l1}}{\rho_{l1}} \frac{\partial P_{Bo}}{\partial q_{Bl1}} q_{Bo1} \\ & + \frac{1-\rho_{l1}}{\rho_{l1}} \delta\lambda \left(\frac{\partial \pi_{A2}}{\partial c_{B2}} + \frac{\partial \pi_{o2}}{\partial c_{B2}} \right) \end{aligned}$$

solves for the industry-profit maximizing outcome.

Chapter 3

Sequential Contract Choice of Strategic Upstream Firms

3.1 Introduction

In legal cases such as Allied Orthopedic Appliances vs. *Tyco* Health Care, Concord Boat Corporation v. *Brunswick* Corporation, and *Intel* v. Commission Decision, the contracts set by the dominant suppliers were suspected to disadvantage rivals or even exclude them.[1] In particular, the contract types ranged from exclusive dealing contracts, agreements on own quantity levels up to market-share discounts. In decisions of allegedly anticompetitive price-based conduct, the question arose whether the rival supplier could defend itself by using specific contractual conditions as well. In *Brunswick*, it is explicitly noted that *"Several of its competitors, including Volvo and OMC, also offered market share discounts at about the same time"* (cf. section I.A. of the Decision). In *Intel*, it is stated that AMD unsuccessfully offered a quantity forcing contract to an original equipment manufacturer (cf. paragraphs 955-957 of the *Intel* Decision).

To analyze the pricing strategies of a dominant supplier and its rival, we investigate a sequential bargaining game where the dominant supplier initially negotiates, and afterwards the rival supplier negotiates with the single downstream firm. That is, in this essay, the dominant supplier is characterized by a temporal advantage over

[1] Allied Orthopedic Appliances, Inc. vs. *Tyco Health Care* Group LP, 592 F:3d 991 (9th Cir. 2010); Concord Boat Corporation v. *Brunswick* Corporation 309 F:3d 494 (8th Cir. 2002); *Intel* v. Commission Decision, 2009, Case COMP/C-3/37.990.

its rival. Both suppliers can, one after the other, strategically choose and negotiate contractual terms.

Following the current discussion on vertical agreements and their pro- as well as anticompetitive effects, we concentrate on three specific contract types. First, the suppliers can negotiate a menu of simple two-part tariffs. The menu consists of an exclusionary and a competitive contract, similar to the menu assumed in Marx and Shaffer (2008). Second, we allow for quantity forcing contracts as a price schedule that refers to the quantity of the contract-offering supplier. Third, we introduce market-share contracts that condition on the relative purchase level and are, above all, legally questionable.

The sequential contracting game allows us to investigate the contract choice of strategic suppliers and the negotiations with the downstream firm. Moreover, we are able to determine the outcome in case of specific assumptions on the bargaining power. The downstream firm could have buyer power vis-à-vis one or both suppliers. For this reason, the buyer power mentioned in the legal decisions, see section 1.1, are reproduced in our framework.

In addition, we assume that suppliers face learning-by-doing effects. These cost reductions related to aggregate former sales occur in innovative markets, like the CPU manufacturing market of Intel and AMD (Cabrera, 2008). As well, they appear in the early stages of a new product (Dasgupta & Stiglitz, 1988). In *Brunswick* as well as *Tyco Health Care*, it is mentioned that the contract designs were chronologically accompanied with the introduction of new products by the dominant firm or its competitor. Therefore the assumption of learning effects seems to suit the representation of the above mentioned cases.

As a first result, we show that learning-by-doing influences the contract choice of the suppliers. In particular, menus of simple two-part tariffs eliminate the double marginalization problem in a single-period sequential bargaining model and achieve the industry-profit maximizing outcome. This outcome is determined similar to Marx and Shaffer (2008). We show that in a two-period model with learning-by-doing, simple two-part tariffs cannot achieve the industry payoff maximizing outcome. This result stems from the individual profit maximizing decision of the downstream firm that considers the learning effects of both suppliers.

In our initial setting, we show that the dominant supplier prefers to negotiate a market-share contract. Choosing this contract type, the dominant supplier and the downstream firm agree upon a relative purchase level besides a fixed fee and wholesale prices. With the relative purchase requirement, the dominant supplier can influence the quantity choice of the downstream firm and, in this way, can achieve the profit maximizing outcome, namely the industry-profit maximizing one. Supposing that the producer surplus is maximal if both goods are sold, market-share contracts do not fully exclude a rival supplier in our setting. This finding directly stems from the rent-shifting fixed fee and the fact that the market-share contract offers enough instruments to modify the downstream firm's quantity choice.

Furthermore, we show that the contractual decision of the rival supplier and the downstream firm has no influence on the final outcome. As simple two-part tariffs, quantity forcing contracts and market-share contracts of the rival supplier will lead to the same final outcome, there is no reason for the rival to deviate from a simple two-part tariff. In this way, our model inter alia explains the inefficacy of a rival's quantity forcing contract in context of a dominant supplier's market-share contract, as for example in case of Intel and AMD.

Comparing the case when the dominant supplier negotiates a market-share contract and the case where market-share contracts are forbidden, we demonstrate that the rival's efficiency gains initiated by learning-by-doing are affected by the contract type. If the downstream firm has relatively high (low) bargaining power vis-à-vis the second supplier, the efficiency gains of the rival are restricted (enhanced) by the market-share contract. The reason for this result stems from the negotiating design, in particular from the outside options. If the buyer power vis-à-vis the rival supplier is relatively large, the downstream firm has a better bargaining position vis-à-vis the rival supplier. This fact leads the downstream firm to favor selling more units of the rival supplier compared to the amount that yields maximum industry profits. Additionally, a relatively large buyer power vis-à-vis the rival supplier improves the bargaining position of the downstream firm when negotiating with the dominant supplier. That is, a simple two-part tariff or a quantity forcing contract set by the dominant supplier cannot fully compensate for the increased consumption of the downstream firm. The market-share contract of the dominant supplier would restrict the purchase level of the rival's good and therefore the efficiency gains of the rival in comparison to the case where market-share contracts are banned. To the contrary, if the bargaining position of the downstream firm is relatively small, the efficiency gains of the rival supplier are enhanced by the dominant supplier's market-share contract. In this case, a ban on market-share contracts would lead to a smaller purchase level of the rival's good and respectively to a restriction of the rival's efficiency gains.

It follows that a general statement about an efficiency restricting tendency of allegedly price-based conduct would be defective (see chapter 2). A ban on market-share contracts can, in the worst case, exclude the rival supplier - even though the presence of the rival would be desirable from the dominant supplier's and a social point of view.

We analyze some variants of the timing of the game. In all considered scenarios, the general result stays the same. The dominant supplier uses a market-share contract, or at least a quantity forcing contract, to achieve the industry profit maximizing outcome and respectively maximum payoffs. The contract offered by the rival supplier does not influence the final outcome as long as specific contractual conditions as for example quantity levels or relative purchase levels can be set by the dominant firm.

Related Literature

First of all, the present model is related to the economic literature on sequential contracting, loyalty discounts and exclusive dealing contracts. In Aghion and Bolton (1987), there is an incumbent firm and a potential entrant that set contracts with a single buyer. Aghion and Bolton show that the incumbent uses a contract that additionally fixes a penalty fee for the case that the buyer agrees upon exclusive dealing with the incumbent, but deviates from the incumbent's contract and purchases the entrant's good. The penalty fee serves to shift rents to the incumbent. Hence, if the potential entrant is relatively efficient, it enters and the incumbent extracts the additional rents. Further models considering entry barriers due to exclusive dealing contracts are inter alia Rasmusen et al. (1991), Segal and Whinston (2000), Fumagalli and Motta (2006), Simpson and Wickelgren (2007) and Wright (2008). All these models consider take-it-or-leave-it contracts offered by the (upstream) firms.

Furthermore, Marx and Shaffer (2008, 2010) analyze single-period sequential bargaining games. In Marx and Shaffer (2008), there are two suppliers of imperfect substitutes that sequentially bargain with a single buyer. If the first supplier can condition its price on the fact whether the second supplier's good is purchased or not, the profitable contract of the first supplier makes the buyer purchase both goods. Wholesale prices are such that the buyer chooses the industry-profit maximizing outcome and fixed fees are used to shift rents from the second supplier upstream. Our initial model especially builds on this article as we allow for menus of contracts where an exclusive contract is used to incentivize the downstream firm to purchase both goods.

Sequential negotiations are also studied by Spier and Whinston (1995), as well as Marx and Shaffer (1999).

Similar to Aghion and Bolton (1987), Ide, Montero, and Figueroa (2015) as well as Choné and Linnemer (2015a, 2015b) deal with sequential bargaining games in set-ups with incomplete information. The models consider that information about the entrant is rare. Neither the production costs nor the demand for the entrant's product are known when the incumbent and the buyer negotiate their contract. The models emphasize the contract choice of the incumbent. Ide et al. (2015) establish a link between the likelihood of entry deterrence by nonlinear contracts and bargaining power of the incumbent vis-à-vis the buyer. Choné and Linnemer (2015a) additionally assume that the buyer can resell units. If the buyer accepts a quantity threshold of the incumbent and, later on, discovers that the quantity overtops its needs, the buyer can throw away or resell unused units. It is shown that the entrant is not fully excluded by conditional contracts such as market-share discounts. Choné and Linnemer (2015b) assume that the entrant has a capacity constraint such that the buyer cannot cover all its needs if it purchases only the entrant's good. In this context it can be shown that a conditional contract may inefficiently exclude the entrant from the market.

In our model, sequential negotiations depict the asymmetry between the first and second supplier. In particular, the dominant supplier is characterized by its first-mover advantage in the sequential setting. Especially with regard to the mentioned legal decisions, we suppose that both suppliers are active firms and negotiate their contract terms one after the other. In this context, we assume complete information, because costs and demand structure of the suppliers could be derived from previous periods.

Bedre-Defolie (2012) analyzes a sequential contracting game where two downstream firms negotiate with a single upstream firm. Leaving out discounts and the possibility to offer menus of contracts, the impact of the negotiating structure on the final outcome is shown. In particular, if the first downstream firm can renegotiate from scratch the modified outside options lead to the industry-profit maximizing outcome. Without these renegotiations, the outcome deviates from the profit-maximizing one. We assume renegotiations from scratch in a variation of the basic model.

Our focus lies on the impact of inter-temporal externalities, especially on learning-by-doing. Doganoglu and Wright (2010) analyze exclusive dealing in a context with network effects in one- and two-sided markets. Karlinger and Motta (2012) also analyze exclusionary contracts in context of network goods.

Our model is also related to the literature on buyer power as we allow for negotiations and bargaining power. Determinants and consequences of buyer power are inter alia investigated by Inderst and Wey (2007, 2011). In addition to the above mentioned models, Allain and Chambolle (2011) studies the role of bargaining power on welfare in a vertical structure where producers can set price-floors. Our model is related to Allain and Chambolle (2011), as we also show, in a different set-up, that buyer power has an impact on long-run efficiency gains and welfare.

The following section presents the initial framework. Section 3.3 investigates the contract choice of the firms in the basic negotiating framework. Section 3.4 presents additional potential negotiating structures as well as their final outcome in comparison to the basic setting. Section 3.5 concludes.

3.2 Framework

There are two upstream firms, supplier A and B, which produce imperfect substitutes. Their marginal costs of production are constant and initially given by c_A, c_B.

Introducing learning-by-doing necessitates a multi-period model. For simplicity, we analyze two periods. In the first period, marginal costs of production are exogenously given. After the first period, learning-by-doing occurs. Second-period marginal costs of production decrease with respect to the industry-specific learning parameter λ and the first-period sales level. That is, $c_{J2} = \max\{0, c_J - \lambda q_{Jt}\}$. The more an upstream firm sells in the first period, the smaller is its marginal cost in period two. Our analysis concentrates on settings where the learning parameter λ is such that $c_{J2} > 0$.

In each of two periods, the suppliers offer their goods to a single monopolistic downstream firm R. R purchases the goods and, in the same period, resells them to final consumers.[2] For simplicity, we assume that costs of distribution are normalized to zero. The inverse demand system is time-invariant. It is characterized by

$$P_A(q_{At}, q_{Bt}),$$
$$P_B(q_{At}, q_{Bt}),$$

where q_{At}, q_{Bt} are quantities sold in period t. We suppose that $P_J(q_{At}, q_{Bt}) \in \mathcal{C}^1$, and $\frac{\partial P_J}{\partial q_{Jt}} < \frac{\partial P_J}{\partial q_{It}} < 0$ whenever $P_J(q_{At}, q_{Bt}) > 0$ for $J, I \in \{A, B\}$.[3]

The downstream firm R could purchase one, both or no goods. It bilaterally negotiates contractual terms with the upstream firms A and B. R possesses bargaining power $\beta_J \in [0, 1]$ vis-à-vis upstream firm $J \in \{A, B\}$. If β_J equals zero, the upstream firm has all bargaining power. In that case, J offers a take-it-or-leave-it contract, which R can (only) accept or reject. If however β_J equals one, the downstream firm has all bargaining power and offers a take-it-or-leave-it contract to the upstream firm. In this case, the upstream firm would act as a competitive fringe. We use the Nash-product to solve for bilateral bargaining.

In our model, both upstream firms face learning effects and both firms act strategically. By this means, the upstream firms generally have the possibility to react on the contract choice of their competitors and thus have influence on the size of their own and their rival's learning effects. In each period, the suppliers negotiate menus of contracts with downstream firm R. We analyze two-part tariffs (T) that implicate a fixed fee F_{Jt} besides the wholesale price w_{Jt}. In addition, we allow for quantity forcing contracts (Q) and market-share contracts (M). A quantity forcing contract sets a specific purchase level q_{Jt}, a wholesale price as well as a fixed fee linked to q_{Jt}. A market-share contract prescribes a specific relative purchase level ρ, a wholesale price w_{Jt} and fixed fee F_{Jt} that is linked to $\rho = \frac{q_{Jt}}{q_{Jt}+q_{It}}$. These contracts

[2]One could also think of the case where the downstream firm can purchase goods in period one, could store them and then sell them in period two. In our set-up with decreasing marginal costs, however, the downstream firm would not make use of this possibility.

[3]For example, these assumptions are fulfilled for the linear demand system $P_A(q_{At}, q_{Bt}) = 1 - q_{At} - \gamma q_{Bt}$, $P_B(q_{At}, q_{Bt}) = 1 - q_{Bt} - \gamma q_{At}$.

correspond, for example, to binding conditional discounts where ρ is the threshold level in case of a market-share discount and q_{Jt} is the threshold sales level in case of a quantity discount where the wholesale price for relative purchase levels or sales levels deviating from ρ or q_{Jt} is infinite.[4]

Timing of the game

We begin with a two-period sequential contracting game where each period consists of three stages. First, the dominant upstream firm A chooses a contract type and negotiates the contractual terms of the contract menu with downstream firm R. Then, upstream firm B chooses a contract type. B and downstream firm R negotiate their contractual terms. Afterwards, downstream firm R sets final prices as well as quantities. After the first period, marginal costs of A and B decrease with respect to first period sales. The second period proceeds in the same way as the first period.

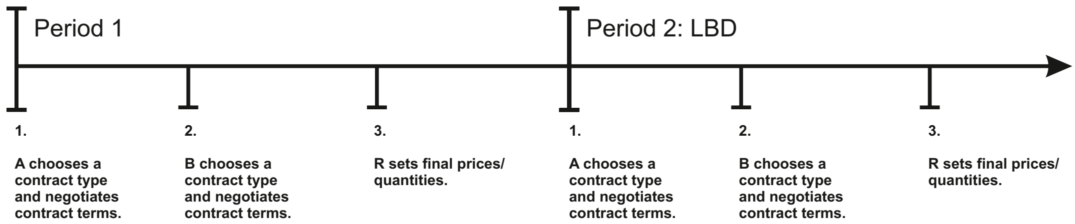


Figure 3.1: Timing of the initial sequential contracting game.

As the negotiating structure is not inevitably traceable or rather not verifiable, we extend the basic model and analyze further structures of negotiations afterwards. The modifications of the timing are described in section 3.4.

For the analysis, we make the following assumptions.

Assumption 3.1 (Industry profits)**.**
The industry profit maximizing quantities q^I_{At}, q^I_{Bt} *and profit* π^I_t *in periods* $t = 1, 2$ *are positive.*

This assumption means that the integrated firm would offer both products to final consumers. In this case, no product is excluded from the market.

[4]We concentrate on the binding discount schemes as non-binding discounts lead to the same outcome as simple two-part tariffs. Further note that the quantity forcing contract operates as a general quantity-price contract, in our set-up.

Assumption 3.2 (Learning)**.**
Marginal costs c_{At}, c_{Bt} *in periods* $t = 1, 2$ *are positive.*

Positive first-period marginal costs mean that learning-by-doing occurs for both suppliers. Positive second-period marginal costs imply that learning does not (already) lead to the most efficient production stage. Due to this assumption, second-period marginal costs depend on first-period sales levels.

In the following, demand parameters and cost functions are common knowledge. In addition, contractual agreements are observable for all firms and, following from the timing, only single-period/short-term contracts are considered.

3.3 Basic model

The initial timing of the game is as indicated above. We allow for menus of contracts, building on Marx and Shaffer (2008). We solve for the sub-game perfect Nash equilibria.

3.3.1 Contract decision in the short run (without learning effects)

First, the results in case without learning-by-doing are represented. That is, we observe the contractual reaction of upstream suppliers in markets where learning-by-doing does not occur or is not taken into account. For this analysis, a single-period model is sufficient because the single-period result will be repeated in a second period.

We (initially) assume the case where the dominant supplier chooses a menu of two-part tariffs. This menu consists of (w^o_{At}, F^o_{At}) which is conditioned on exclusivity, and (w^c_{At}, F^c_{At}) which is conditioned on competition. The rival supplier offers a simple two-part tariff (w_{Bt}, F_{Bt}).

The three-stage game is solved by backwards induction.

Stage 3 - Downstream firm's quantity decision

Downstream firm R has the choice to purchase one good, both goods or nothing. If it purchases only the good of supplier A, R chooses

$$q^o_{At}(w^o_{At}) = \arg\max(P_A(q_{At}, 0) - w^o_{At})q_{At} - F^o_{At}.$$

If R purchases only B's good, it chooses

$$q^o_{Bt}(w_{Bt}) = \arg\max(P_B(0, q_{Bt}) - w_{Bt})q_{Bt} - F_{Bt}.$$

When both goods are purchased, the downstream firm chooses

$$\begin{aligned}&(q_{At}(w^c_{At}, w_{Bt}), q_{Bt}(w^c_{At}, w_{Bt})) = \\ &\qquad \arg\max(P_A(q_{At}, q_{Bt}) - w^c_{At})q_{At} + (P_B(q_{At}, q_{Bt}) - w_{Bt})q_{Bt} - F^c_{At} - F_{Bt}.\end{aligned}$$

Stage 2 - Negotiation of second supplier and downstream firm

In stage two, the second supplier B and downstream firm R negotiate a two-part tariff that will maximize their joint payoff. If the negotiation between A and R in stage one failed, the optimization problem of supplier B and downstream firm R is

$$\max\left((P_B(0, q^o_{Bt}(w_{Bt})) - w_{Bt})q^o_{Bt}(w_{Bt}) - F_{Bt}\right)^{\beta_B} \cdot \left(q^o_{Bt}(w_{Bt}) \cdot (w_{Bt} - c_{Bt}) + F_{Bt}\right)^{1-\beta_B}.$$

Nash bargaining makes the firms maximize their aggregate payoff and distribute it according to their bargaining power and outside options. The outside options of B and R are zero. This is because the negotiation between supplier A and downstream firm R failed in stage one, and there is no opportunity to negotiate with another firm after stage 2. Thus, the maximum aggregate payoff of B and R is simply divided according to the buyer power β_B. The negotiated two-part tariff is $(w_{Bt}, F_{Bt}) = (c_{Bt}, (1-\beta_B)\pi_t^{(B)})$, where $\pi_t^{(B)} = \max(P_B(0, q_{Bt}) - c_{Bt})q_{Bt}$ is the maximum payoff that B and R can achieve together. The outcome that leads to $\pi_t^{(B)}$ is denoted q^o_{Bt}.

In contrast, if the negotiation between A and R is successful and R purchases both goods, the optimization problem is

$$\begin{aligned}\max\Big(&(P_A(q_{At}(w^c_{At}, w_{Bt}), q_{Bt}(w^c_{At}, w_{Bt})) - w^c_{At})q_{At}(w^c_{At}, w_{Bt}) \\ &+(P_B(q_{At}(w^c_{At}, w_{Bt}), q_{Bt}(w^c_{At}, w_{Bt})) - w_{Bt})q_{Bt}(w^c_{At}, w_{Bt}) - F_{At} - F_{Bt} - \beta_A\pi_t^{(A)}(w^o_{At}, F^o_{At})\Big)^{\beta_B} \\ &\cdot\left(q_{Bt}(w^c_{At}, w_{Bt}) \cdot (w_{Bt} - c_{Bt}) + F_{Bt}\right)^{1-\beta_B}\end{aligned}$$

The outside option of R in the negotiation with B is given by
$\beta_A \pi_t^{(A)}(w^o_{At}, F^o_{At}) = \beta_A(P_A(q^o_{At}(w^o_{At}), 0) - c_{At})q^o_{At}(w^o_{At})$.[5]
It is the payoff that R achieves if it only negotiates with A. The outside option of supplier B is zero again, because there is no other downstream firm that could negotiate with B. Nash bargaining leads to the two-part tariff

$$(w_{Bt}, F_{Bt}) = (c_{Bt}, (1-\beta_B)\{\overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) - \beta_A \pi_t^{(A)}(w^o_{At}, F^o_{At})\}),$$

where $\overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) = (P_A(q_{At}(w^c_{At}, c_{Bt}), q_{Bt}(w^c_{At}, c_{Bt})) - w^c_{At})q_{At}(w^c_{At}, c_{Bt}) + (P_B(q_{At}(w^c_{At}, c_{Bt}), q_{Bt}(w^c_{At}, c_{Bt})) - c_{Bt})q_{Bt}(w^c_{At}, c_{Bt}) - F^c_{At}$. The downstream firm and supplier B maximize their aggregate payoffs by setting the wholesale price equal to marginal costs. Payoffs of supplier B and downstream firm R depend on the contract menu of supplier A and are given by

$$\pi_{Rt}(w^c_{At}, F^c_{At}, w^o_{At}, F^o_{At}) = \beta_B \overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) + (1-\beta_B)\beta_A \pi_t^{(A)}(w^o_{At}, F^o_{At}),$$
$$\pi_{Bt}(w^c_{At}, F^c_{At}, w^o_{At}, F^o_{At}) = (1-\beta_B)\overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) - (1-\beta_B)\beta_A \pi_t^{(A)}(w^o_{At}, F^o_{At}).$$

Stage 1 - Negotiation of first supplier and downstream firm

In the first stage, supplier A and downstream firm R negotiate the contractual terms of the contract menu. If negotiations between A and R fail, the downstream firm would purchase only B's good and earn $\beta_B \pi_t^{(B)}$. That is the outside option in the first stage negotiation. Furthermore, the downstream firm could accept the contract menu with upstream firm A and skip negotiations with supplier B in stage 2. In that case, R would use the exclusionary contract and earn $\beta_A \pi_t^{(A)}(w^o_{At}, F^o_{At})$. As however joint payoffs of A and R are larger when both goods are purchased, the exclusionary contract is used to incentivize R to purchase both goods. Therefore, the optimization problem in stage one is

$$\begin{aligned}
&\max \left(\pi_{Rt}(w^c_{At}, F^c_{At}, w^o_{At}, F^o_{At}) - \beta_B \pi_t^{(B)}\right)^{\beta_A} \cdot \left(q_{At}(w^c_{At}, c_{Bt}) \cdot (w^c_{At} - c_{At}) + F^c_{At}\right)^{1-\beta_A}, \\
&\text{s.t. } \pi_{Rt}(w^c_{At}, F^c_{At}, w^o_{At}, F^o_{At}) \geq \beta_A \pi_t^{(A)}(w^o_{At}, F^o_{At}) \qquad (3.1)
\end{aligned}$$

Condition (3.1) is similar to $\overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) \geq \beta_A \pi_t^{(A)}(w^o_{At}, F^o_{At})$. Thus, the incentive compatibility constraint of R implies the participation of upstream firm B.

[5] Additionally, there are two side conditions to be considered. Namely, both factors of the Nash product have to be positive (at least zero). In the following, the side conditions are always considered.

The negotiated contract menu is given by

$$\begin{aligned}
&(w^c_{At}, F^c_{At}) = (c_{At}, (1-\beta_A)\pi^I_t - (1-\beta_A)\beta_B\pi^{(B)}_t), \text{ and}\\
&(w^o_{At}, F^o_{At}) \text{ such that } \overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) = \beta_A\pi^{(A)}_t(w^o_{At}, F^o_{At}).
\end{aligned}$$

Respectively, the industry-profit maximizing outcome q^I_{At}, q^I_{Bt} is achieved. Payoffs are given by

$$\begin{aligned}
\pi^*_{At} &= (1-\beta_A)\pi^I_t - (1-\beta_A)\beta_B\pi^{(B)}_t,\\
\pi^*_{Bt} &= 0,\\
\pi^*_{Rt} &= \beta_A\pi^I_t + (1-\beta_A)\beta_B\pi^{(B)}_t.
\end{aligned}$$

Aggregate payoffs equal maximum industry profits $\pi^{(I)}_t$. They are subdivided according to the first-stage outside option and buyer power β_A. Note that the second supplier makes zero profits. The reason is that the contract menu of supplier A and downstream firm R works as a rent-shifting device. The exclusionary contract is used for the incentive compatibility of the downstream firm. The fixed fee F^c_{At} is a component of the profits of the second supplier. In this way, it is used to shift all rents of supplier B up to supplier A and downstream firm R.

As the dominant supplier A would not deviate from using a fixed fee F^c_{At}, rent shifting occurs independently of further contract types of the second supplier. In addition, the dominant supplier has no incentive to deviate from (menus of) simple two part tariffs. These contracts already lead to maximum industry profits and hence maximum payoffs for supplier A.

Note that the outcome drastically depends on the fact that the first upstream supplier can negotiate menus of contracts. Without the exclusionary component in the menu, the incentive compatibility and participation of supplier B would not be ensured. If menus, especially exclusionary contracts, were forbidden, the dominant supplier would need another device to implement the exclusionary component. For example, supplier A could set a rebate level that implies the exclusionary case.

Quantities q^I_{At}, q^I_{Bt} and payoffs π^*_{Jt}, $J \in \{A, R\}$ depend on marginal costs c_{At} and c_{Bt}. In the following, we will denote quantities by $q^I_{At}(c_{At}, c_{Bt})$, $q^I_{Bt}(c_{At}, c_{Bt})$ and payoffs by $\pi^*_{Jt}(c_{At}, c_{Bt})$.[6]

[6]Note that if we consider long-term contracts negotiated by both suppliers in the first period, the industry-profit maximizing outcome is also achieved.

3.3.2 Contract decision with learning-by-doing

In the two-period model with learning effects, the analytical steps that were used in section 3.3.1 are applicable as well. In the second period, the upstream firms set menus of simple two-part tariffs as determined above. The first-period decisions affect second-period outcomes. In other words, the firms consider their second-period payoffs in the negotiations and sales decisions in the first period. Therefore, long-run payoffs $\Pi_J(q_{A1}, q_{B1}) = \pi_{J1}(q_{A1}, q_{B1}) + \delta\pi^*_{J2}(c_{A2}, c_{B2})$ are taken into account in period one, where $\delta \in (0, 1)$ is the (time-)discount factor and with assumption 3.2, marginal costs are given by $c_{J2} = c_J - \lambda q_{J1}$, $J \in \{A, B\}$.

To analyze the first period and to guarantee that there is a unique equilibrium, the following assumptions are made.

Assumption 3.3 (Uniqueness I)**.**
Long-run industry profits are given by

$$\Pi_I(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - c_A)q_{A1} + (P_B(q_{A1}, q_{B1}) - c_B)q_{B1} + \delta\pi^I_2(c_{A2}, c_{B2}),$$

long-run payoffs of downstream firm R are given by

$$\Pi_R(q_{A1}, q_{B1}) = (P_A(q_{A1}, q_{B1}) - w_{A1})q_{A1} + (P_B(q_{A1}, q_{B1}) - w_{B1})q_{B1} + \delta\pi^*_{R2}(c_{A2}, c_{B2}).$$

For both functions, the Hessian matrix is negative definite.

Assumption 3.4 (Uniqueness II)**.**
If a supplier is indifferent between contract types, it chooses the simplest of these contract designs. That is, out of this set of contracts, it chooses the contract type with the lowest number of instruments.

Assumption 3.3 is necessary to determine the optimal outcome in case of all specific contract combinations. Assumption 3.4 is used to determine a unique sub-game perfect equilibrium. As shown in section 3.3.1, the suppliers are indifferent between all contract types in period two of the two-period game. That is, every contract combination leads to an equilibrium in the second period. Under assumption 3.4, we concentrate on the contract combinations that are relatively simple because in this case the application of further contract specifications is unnecessary. Therefore, we consider that in the second period of the game, both suppliers choose simple two-part tariffs and the downstream firm chooses $q^I_{A2}(c_{A1}, c_{B1})$ and $q^I_{B2}(c_{A1}, c_{B1})$. In the first period, the contract choice of the suppliers can generally have an influence on the outcome. That is, we consider and calculate all outcomes of the contractual combinations of supplier A and B to determine the sub-game perfect equilibrium of the two-period game.

In the following, we start with the case of simple two-part tariffs used by both suppliers. Then, we allow for quantity-price contracts, used by supplier A, supplier B or both. Last, we allow for market-share contracts.[7] The extensive form of the dynamic game, is depicted in figure 3.2.

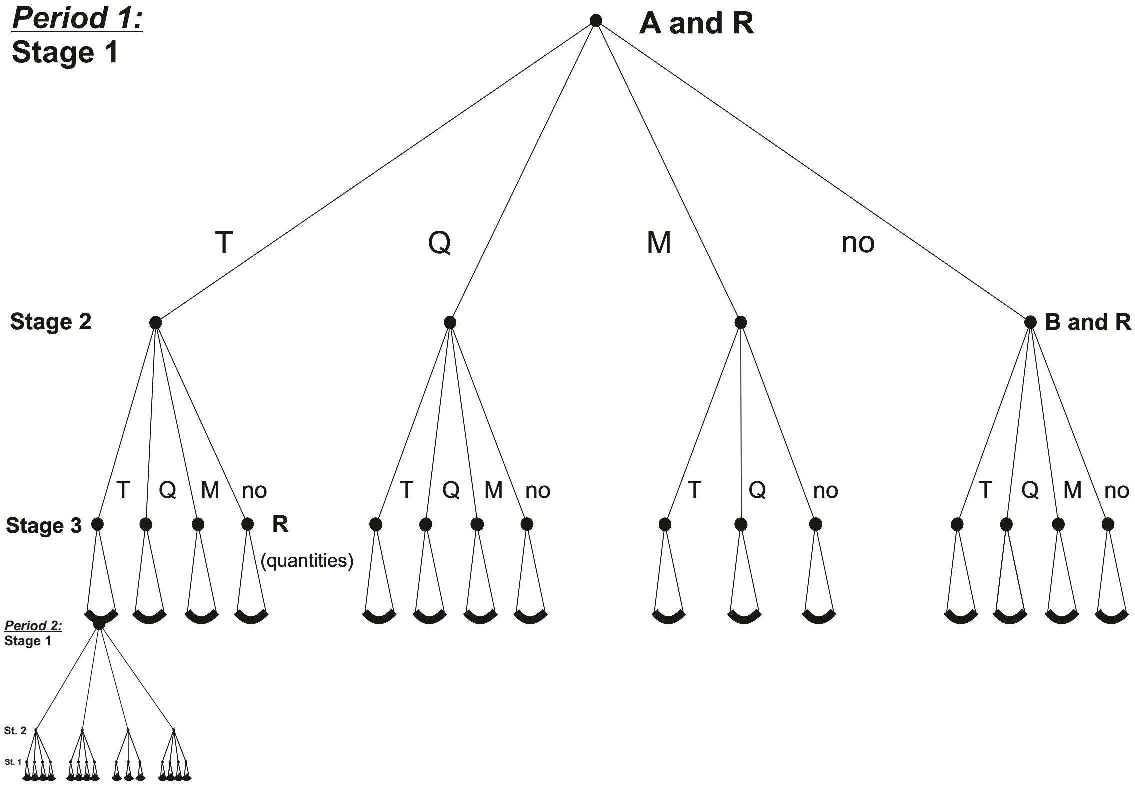


Figure 3.2: Extensive form of the two-period game.

[7]Note that an analysis with general contracts conditioning on one or both quantity levels ($T(q_{At}, q_{Bt})$) is not possible. The reason is that the contract choice of the suppliers influence the quantity choice of the downstream firm. Therefore, we commit ourselves to the mentioned contract designs.

3.3.2.1 Two-part tariffs

For the time being, suppose that upstream firms negotiate menus of simple two-part tariffs (in period one). Hereafter we present the calculation steps and results of the first-period.[8]

Stage 3

Following the backwards induction in period one, we begin with stage three of the bargaining game. Here, the downstream firm maximizes its long-run payoffs with respect to both quantities q_{A1} and q_{B1}. If the downstream firm purchases exclusively from supplier A, it chooses $q^o_{A1}(w^o_{A1})$, given by

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + P_A(q_{A1}, 0) - w^o_{A1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} = 0.$$

If downstream firm R purchases only the good of supplier B, R would choose $q^o_{B1}(w_{B1})$ in a similar way. If R decides to purchase both goods, it chooses $q_{A1}(w^c_{A1}, w_{B1})$, $q_{B1}(w^c_{A1}, w_{B1})$ according to

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - w^c_{A1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} = 0, \tag{3.2}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - w_{B1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0. \tag{3.3}$$

In each case, downstream firm R considers the impact of learning-by-doing on its own payoff ($\frac{\partial \pi^*_{R2}}{\partial c_{J2}}$, $J = A, B$). Note that the decision of R implies that the joint-payoff maximizing outcome would not be achieved by setting wholesale prices equal to marginal costs. The reason is that R does not keep in mind the impact of learning on the suppliers' payoffs, in particular the payoff of supplier A. In this way, the decision of R (considering learning-by-doing) deviates from the one without learning effects.

Stage 2

In stage two, the second supplier and the downstream firm negotiate the terms of a two-part tariff. If supplier B and downstream firm R deal exclusively, the

[8] A detailed version of calculations to this section can be found in the appendix, section 3.6.

optimization problem is given by

$$\max \left((P_B(0, q^o_{B1}(w_{B1})) - w_{B1}) q^o_{B1}(w_{B1}) - F_{B1} + \delta\pi^*_{R2}(c_A, c_{B2}) \right)^{\beta_B} \\ \cdot \left(q^o_{B1}(w_{B1}) \cdot (w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_A, c_{B2}) \right)^{1-\beta_B}.$$

The resulting two-part tariff achieves the outcome that makes B and R maximize their joint payoffs, $\Pi^{(B)} = \max(P_B(0, q_{B1}) - c_B)q_{B1} + \delta\pi^*_{R2}(c_A, c_{B2})$. As before, the distribution of joint payoffs between supplier B and firm R depends on the bargaining power β_B. The payoff of R would be $\Pi^{(B)}_R = \beta_B\Pi^{(B)}$, the payoff of supplier B $\Pi^{(B)}_B = (1 - \beta_B)\Pi^{(B)}$.

If supplier A and downstream firm R negotiate a menu of contracts in stage one, supplier B and firm R optimize

$$\max \left(\Pi_R(w^c_{A1}, F^c_{A1}, w_{B1}, F_{B1}) - \Pi^{(A)}_R(w^o_{A1}, F^o_{A1}) \right)^{\beta_B} \cdot \left(\Pi_B(w^c_{A1}, w_{B1}, F_{B1}) - 0 \right)^{1-\beta_B},$$

where $\Pi_R(w^c_{A1}, F^c_{A1}, w_{B1}, F_{B1}) = (P_A(q_{A1}(w^c_{A1}, w_{B1}), q_{B1}(w^c_{A1}, w_{B1})) - w^c_{A1})q_{A1}(w^c_{A1}, w_{B1}) + (P_B(q_{A1}(w^c_{A1}, w_{B1}), q_{B1}(w^c_{A1}, w_{B1})) - w_{B1})q_{B1}(w^c_{A1}, w_{B1}) - F^c_{A1} - F_{B1} + \delta\pi^*_{R2}(c_{A2}, c_{B2})$
is the profit of firm R depending on the two-part tariffs, and the profit of supplier B is
$\Pi_B(w^c_{A1}, w_{B1}, F_{B1}) = q_{B1}(w^c_{A1}, w_{B1}) \cdot (w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2}, c_{B2})$.
$\Pi^{(A)}_R(w^o_{A1}, F^o_{A1}) = (P_A(q^o_{A1}(w^o_{A1}), 0) - w^o_{A1})q^o_{A1}(w^o_{A1}) - F^o_{A1} + \delta\pi^*_{R2}(c_{A2}, c_B)$ is the outside option of downstream firm R.

The arising two-part tariff between B and R includes $w^T_{B1} = c_B$. Again, the wholesale price w^T_{B1} makes R maximize cumulated payoffs of B and R. The reason is that there is no impact of learning-by-doing on the second-period payoff of B, $\pi^*_{B2}(c_{A2}, c_{B2}) = 0$.[9] Therefore, the quantity choice of downstream firm R includes the impact of learning on cumulated payoffs of B and R. Cumulated payoffs are divided with respect to bargaining power β_B and the outside option of downstream firm R in stage two ($\Pi^{(A)}_R(w^o_{A1}, F^o_{A1})$). Similar to the case without learning effects, we get payoffs $\Pi_R(w^c_{A1}, F^c_{A1}, w^o_{A1}, F^o_{A1})$ and $\Pi_B(w^c_{A1}, F^c_{A1}, w^o_{A1}, F^o_{A1})$.

[9] Whenever π^*_{B2} is positive, the quantity choice of the downstream firm does not maximize cumulated payoffs of B and R, see section 3.4.

Stage 1

In stage one, the optimization problem of supplier A and downstream firm R is now given by

$$\max \left(\Pi_R(w^c_{A1}, F^c_{A1}, w^o_{A1}, F^o_{A1}) - \Pi^{(B)}_R\right)^{\beta_A}$$
$$\cdot \left(q_{A1}(w^c_{A1}, c_B) \cdot (w^c_{A1} - c_A) + F^c_{A1} + \delta\pi^*_{A2}(c_{A2}, c_{B2})\right)^{1-\beta_A}$$
$$\text{s.t. } \Pi_R(w^c_{A1}, F^c_{A1}, w^o_{A1}, F^o_{A1}) \geq \Pi^{(A)}_R(w^o_{A1}, F^o_{A1})$$

Here, the negotiated wholesale price of the competitive contract deviates from marginal costs. It is given by

$$w^{T,c}_{A1} = c_A + \delta\lambda\left(\frac{\partial\pi^*_{A2}}{\partial c_{A2}} + \frac{\partial\pi^*_{A2}}{\partial c_{B2}}\frac{\partial q_{B1}(w^{T,c}_{A1}, c_B)/\partial w^{T,c}_{A1}}{\partial q_{A1}(w^{T,c}_{A1}, c_B)/\partial w^{T,c}_{A1}}\right).$$

The wholesale price $w^{T,c}_{A1}$ influences the quantity choice of the downstream firm according to the effects of learning-by-doing on profits of supplier A. Yet (as a single instrument), it cannot make R consider industry profits when choosing final prices. In contrast to the benchmark case in section 3.3.1, simple two-part tariffs do not solve for the cumulated payoff-maximizing outcome in stage one of the first-period game. The deviation from the respective outcome to the joint-payoff maximizing outcome stems from the impact of learning-by-doing of the second supplier on the dominant supplier's payoff ($\frac{\partial\pi^*_{A2}}{\partial c_{B2}}$). In addition, note that the wholesale price of A can be below or above cost. It depends on the bargaining power of the downstream firm vis-à-vis supplier B.[10]

Consequently, the firms have an incentive to change their contract design. Next, we introduce different combinations of contract types of supplier A and B.

3.3.2.2 Quantity forcing

There are three possible combinations where at least one supplier negotiates a quantity forcing contract. First, the dominant supplier could use quantity forcing while the rival supplier uses two-part tariffs (a). Second, the rival supplier could use quantity forcing while the dominant supplier uses a menu of simple two-part tariffs (b). Third, both suppliers could use quantity forcing (c).

[10] The first summand is negative, $\frac{\partial\pi^*_{A2}}{\partial c_{A2}} = (1-\beta_A)(-q^I_{A2}) < 0$. The second summand can be positive or negative, depending on β_B, because $\frac{\partial\pi^*_{A2}}{\partial c_{B2}} = (1-\beta_A)(\beta_B q^o_{B2} - q^I_{B2}) \gtrless 0$, and $\frac{\partial q_{B1}/\partial w^{T,c}_{A1}}{\partial q_{A1}/\partial w^{T,c}_{A1}} < 0$ according to the implicit function theorem.

We point out the specific characteristics of the contract combinations (a)-(c) in comparison to the case of simple two-part tariffs, presented in section 3.3.2.1. Detailed calculations can be found in the appendix, section 3.6.

(a) If only the dominant supplier uses quantity forcing, the downstream firm and the dominant supplier would fix the quantity q_{A1} in the contract menu. That is, the stage-three quantity decision of downstream firm R solely refers to q_{B1}. In particular, if R purchases both goods, it chooses $q_{B1}(q^c_{A1}, w_{B1})$ according to equation (3.3). Note that the quantity choice does not depend on the wholesale price of supplier A anymore.

    In stage two, the two-part tariff of B and R leads to the quantity of B that maximizes the cumulated profit of supplier B and downstream firm R due to a similar argumentation as in case of two-part tariffs.[11] The negotiated wholesale price is $w_{B1} = c_B$, independent of whether downstream firm R purchases only the good of supplier B or both goods.

    In stage one, the dominant supplier negotiates the wholesale prices w^c_{A1}, w^o_{A1}, fixed fees F^c_{A1}, F^o_{A1} and quantity levels q^c_{A1}, q^o_{A1} for the exclusive and the competitive contract in the menu. As before, the exclusive contract makes R purchase both goods. The competitive contract is the one that is applied. In general, quantity forcing contracts offer an additional instrument compared to simple two-part tariffs, namely the fixed quantity level. However, in the given set-up the additional contractual term cannot perfectly influence the outcome such that maximum industry payoffs are achieved. The reason is that only the quantity level q_{A1} influences the quantity choice of the downstream firm and this single instrument cannot solve for the industry-profit maximizing outcome.

(b) If the second supplier uses quantity forcing, and the first supplier negotiates a menu of simple two-part tariffs, the quantity q_{B1} is set in the negotiations between supplier B and downstream firm R. That is, if both goods are purchased, the downstream firm chooses $q_{A1}(w^c_{A1}, q_{B1})$ in stage three of period one, characterized by equation (3.2).

[11] Note that in case of $\pi^*_{B2} \neq 0$, the decision is different from the one in case of simple two-part tariffs, see section 3.4.

In stage two, supplier B and downstream firm R negotiate a quantity forcing contract that maximizes their joint payoff. That is, the quantity level is set such that it maximizes cumulated payoffs of B and R. The wholesale price and fixed fee have no influence on R's quantity choice. They both serve to distribute payoffs between supplier B and downstream firm R. The reason is similar to the above mentioned cases.

In stage one of the first period, the dominant supplier A and downstream firm R negotiate a menu of simple two-part tariffs. Here, the fixed fee of the competitive contract shifts rents and the wholesale price has an influence on the quantity choice of downstream firm R. However, the wholesale price as a single instrument does not achieve the industry-profit maximizing outcome.

(c) If both suppliers use quantity forcing, both quantity levels are set in the negotiations. That is, the decision of the downstream firm in stage three is omitted.

In stage two, supplier B and downstream firm R negotiate the wholesale price, fixed fee and the quantity level depending on the contract between supplier A and downstream firm R. Particularly, the negotiated quantity level $q_{B1}(q^c_{A1})$ only depends on the quantity of supplier A but not on the wholesale price. Analogously to the cases above, it maximizes the joint payoff of supplier B and downstream firm R.

In stage one, supplier A and downstream firm R negotiate a wholesale price, fixed fee and quantity level for the exclusive and competitive contract of the menu. As before, the exclusive contract incentivizes R to purchase both goods. The competitive contract is used to shift rents and to influence the quantity choice of supplier B and downstream firm R. As however q_{B1} only depends on the quantity level q^c_{A1}, the case is similar to (a). The wholesale price w^c_{A1} and fixed fee F^c_{A1} are used to shift rents and q^c_{A1} affects the quantity q_{B1}. As before, the industry-profit maximizing outcome cannot be achieved.

In sum, all three combinations cannot achieve the industry-profit maximizing outcome. In all cases, the stage-two outcome maximizes the cumulated payoffs of the second supplier and the downstream firm, depending on the contract menu of the first supplier and the downstream firm. The reason for this result stems from the fact that second-period payoffs of supplier B are zero. In this way, the downstream firm and supplier B negotiate contract terms to maximize their cumulated payoffs.[12] However, the contract (menu) of the first supplier offers only a single instrument that influences the quantity decision of the downstream firm. Due to the impact of learning-by-doing of both suppliers on the payoffs of A and R, two instruments are necessary to adjust the decision about both quantity levels. In particular, the deviation from the industry-profit maximizing outcome stems from the impact of learning of the rival supplier on the dominant supplier's payoff ($\frac{\partial \pi^*_{A2}}{\partial c_{B2}}$). If only the dominant supplier had learning effects and the efficiency in production of the rival supplier remained the same, the quantity forcing contracts or simple two-part tariffs of the dominant supplier would achieve the industry-payoff maximizing outcome.

The following proposition characterizes the outcome for all three combinations.

Proposition 3.1 (Quantity forcing).
If one or both suppliers negotiate (menus of) quantity-forcing contracts with downstream firm R, the outcome in period one is q^T_{A1}, q^T_{B1}, characterized by

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}(q_{A1})) - c_A - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{A2}} - \delta\lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(q_{A1})}{\partial q_{A1}} = 0 \tag{3.4}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} + \delta\lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} = 0 \tag{3.5}$$

The outcome in period two is $q^I_{A2}(c^T_{A2}, c^T_{B2})$, $q^I_{B2}(c^T_{A2}, c^T_{B2})$, where $c^T_{J2} = c_J - \lambda q^T_{J1}$ and $J = A, B$.

The proof is delegated to the appendix.

As a last step, we introduce market-share contracts.

3.3.2.3 Market-share contracts

Allowing for market-share contracts extends the number of potential contract combinations. The dominant supplier could negotiate a market-share contract while the rival supplier negotiates a simple two-part tariff or a quantity forcing contract

[12] If second-period payoffs of supplier B depend on second-period marginal costs, the result changes, see the calculations in the appendix, section 3.6.

(a). Further, the rival supplier could negotiate a market-share contract with downstream firm R while the dominant supplier uses simple two-part tariffs or quantity forcing contracts (b). As a last option, both suppliers could (theoretically) negotiate market-share contracts. This last scenario however seems rather unrealistic. If the dominant supplier negotiates a market-share contract with downstream firm R, it would be questionable why the rival supplier B and firm R should negotiate a market share which must then result in the same proportional amount as set by supplier A and downstream firm R. According to that argumentation we do not analyze the scenario with market-share contracts of both suppliers and rather concentrate on the contract combinations recorded as (a) and (b).

a) First, the dominant supplier A could negotiate a menu of market-share contracts with downstream firm R and the rival supplier B could negotiate a simple two-part tariff with R. In this case, the relative purchase level $\rho_{A1} = \frac{q_{A1}}{q_{A1}+q_{B1}}$ is fixed by the market-share contract of A and R. Thus, the downstream firm decides about the aggregate quantity or respectively one single quantity q_{A1}, where $q_{B1} = \frac{1-\rho_{A1}}{\rho_{A1}} q_{A1}$. If R purchases both goods, the quantity decision of R is characterized by

$$0 = \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1} + P_A(q_{A1}, \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1}) - w^c_{A1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}}$$
$$+ \frac{1-\rho^c_{A1}}{\rho^c_{A1}} \left(\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1} + P_B(q_{A1}, \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1}) - w_{B1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} \right).$$

In contrast to the previous cases, the quantity choice depends on both wholesale prices as well as the share of purchases ρ^c_{A1}.

In stage two again, the contract between rival supplier B and downstream firm R implies $w_{B1} = c_B$. That is, the simple two-part tariff leads to the outcome that maximizes cumulated payoffs of B and R, depending on the market-share contracts of A and R.

In stage one, the dominant supplier and the downstream firm use the exclusive contract for incentive compatibility.[13] The competitive contract has three instruments that are in use: The fixed fee is used to shift rents from the rival supplier to the dominant supplier and the downstream firm. The wholesale price w^c_{A1} as well as the market share ρ^c_{A1} have an influence on the quantity

[13] The market share is 1 in the exclusionary case.

choice of R. These two instruments suffice to affect the quantity choices of the downstream firm. As shown in section 3.6, the menu of market-share contracts therefore solves for the industry-profit maximizing outcome.

Second, the rival supplier could negotiate a quantity forcing contract. In that case, the downstream firm has no decision in stage three because the quantity level q_{B1} is fixed in the negotiation with supplier B and the relative purchase level, hence $q_{A1} = \frac{\rho_{A1}}{1-\rho_{A1}} q_{B1}$, is fixed in the market-share contract of A and R.

In stage two the rival supplier and downstream firm R negotiate the quantity level q_{B1} that maximizes cumulated payoffs of B and R due to similar reasons as already presented. Here, q_{B1} depends on the wholesale price and the market share negotiated by supplier A and downstream firm R.

In stage one, the negotiation of supplier A and downstream firm R therefore proceeds in a similar way as the negotiation in case of a simple two-part tariff of supplier B. The final outcome equals the industry-profit maximizing one.

b) The second supplier could solely negotiate a market-share contract with downstream firm R, and the first supplier could negotiate a menu of simple two-part tariffs. In this case, the quantity choice of downstream firm R refers to the aggregate quantity, alternatively the single quantity q_{A1}, while $q_{B1} = \frac{\rho_{B1}}{1-\rho_{B1}} q_{A1}$, if both goods are purchased. q_{A1}, in dependence of the wholesale prices and market share ρ_{B1} is characterized by

$$\frac{1-\rho_{B1}}{\rho_{B1}} \left(\frac{\partial P_A}{\partial q_{A1}} \frac{1-\rho_{B1}}{\rho_{B1}} q_{B1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(\frac{1-\rho_{B1}}{\rho_{B1}} q_{B1}, q_{B1}) - w^c_{A1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} \right)$$
$$\frac{\partial P_A}{\partial q_{B1}} \frac{1-\rho_{B1}}{\rho_{B1}} q_{B1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(\frac{1-\rho_{B1}}{\rho_{B1}} q_{B1}, q_{B1}) - w_{B1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0.$$

Similar to 3.3.2.2.a, the outcome in stage two of period one maximizes cumulated payoffs of B and R.

In stage one, supplier A and downstream firm R negotiate a menu of simple two-part tariffs. As only the wholesale price of the competitive contract influences the quantity choice of the rival supplier and downstream firm R, a market-share contract of supplier B and downstream firm R does not lead to the industry-profit maximizing outcome.

Analogously, it is shown in the appendix, section 3.6, that a market-share contract between B and R and a menu of quantity forcing contracts between

A and R lead to a similar argumentation and same outcome as in case of simple two-part tariffs negotiated by A and R.

Proposition 3.2 (Market-share contracts).
If the first supplier uses market-share contracts, the industry-profit maximizing outcome is achieved. In period one, the outcome q^I_{A1}, q^I_{B1} *is characterized by*

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \delta\lambda \frac{\partial \pi_2^I}{\partial c_{A2}} = 0, \tag{3.6}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda \frac{\partial \pi_2^I}{\partial c_{B2}} = 0. \tag{3.7}$$

In period two, the outcome is $q^I_{A2}(c^I_{A2}, c^I_{B2})$, $q^I_{B2}(c^I_{A2}, c^I_{B2})$, *with* $c^I_{A2} = c_A - \lambda q^I_{A1}$ *and* $c^I_{B2} = c_B - \lambda q^I_{B1}$.
If only the second supplier sets a market-share contract, the first-period outcome would be q^T_{A1}, q^T_{B1}. *The second-period outcome would be* $q^I_{A2}(c^T_{A2}, c^T_{B2})$, $q^I_{B2}(c^T_{A2}, c^T_{B2})$.

The proof is delegated to the appendix.

The previous subsections show all outcomes of the assumed contract combinations. Taking these outcomes into consideration, we are able to determine the subgame perfect Nash equilibrium. In particular, the results show, that in equilibrium, the dominant supplier uses market-share contracts in period one, supplier B chooses a simple two-part tariff in period one, the downstream firm chooses quantities q^I_{A1}, q^I_{B1}, supplier A chooses simple two-part tariffs in period two, supplier B chooses simple two-part tariff in period 2 and downstream firm R chooses $q^I_{A2}(c^I_{A1}, c^I_{B1})$, $q^I_{B2}(c^I_{A1}, c^I_{B1})$.

That is, the industry-profit maximizing outcome is achieved in equilibrium. Furthermore, the calculations show that the contract choice of the second supplier has no influence on the final outcome. The second supplier could negotiate a simple two-part tariff, a quantity forcing contract or a market-share contract. Yet, all contract types lead to the same outcome that only relies on the contract choice of the dominant supplier. Even if the dominant supplier used a simple two-part tariff, the rival supplier would have no incentive to offer additional contractual conditions. Therefore, the framework analyzed here cannot explain why a rival supplier should use a specific contract type in addition to a simple two-part tariff. The reason lies in the total rent shifting caused by the contract menu of the dominant supplier.

The rival supplier gets zero profit, and has consequently no incentive to modify its contractual offer. See section 3.4 for an alternative negotiating structure.

Besides, it follows that the cost reduction of the second supplier, hence its efficiency gains, depends on the contract choice of the dominant supplier, but not on the contract between the rival supplier and the downstream firm.

3.3.3 Efficiency and welfare implications

Next, we discuss the consequences of the contract choice on efficiency gains and welfare. Based on the analysis above the question arises whether (and how) market-share contracts by a dominant supplier affect the efficiency of the rival supplier. We compare the equilibrium outcome determined in section 3.3.2 with the outcome that results when market-share contracts are forbidden. As investigated, the former case leads to q^I_{A1}, q^I_{B1} in period one given by (3.6) and (3.7), the latter case leads to q^T_{A1}, q^T_{B1} given by (3.4) and (3.5). By comparing the corresponding first-order conditions, the impact of a dominant supplier's market-share contract on the efficiency gains of a rival supplier can be identified.

Corollary 3.1 (Efficiency gains)**.**
Suppose that the bargaining power of the downstream firm vis-à-vis the dominant supplier β_A is smaller than one. For the unique level of bargaining power $\hat{\beta}_B$ of downstream firm R vis-à-vis supplier B, a menu of simple two-part tariffs of supplier A and downstream firm R leads to the same outcome as market-share contracts, namely to the industry profit maximizing quantity levels.

If however the bargaining power is relatively large, that is $\beta_B > \hat{\beta}_B$, a menu of market-share contracts restricts the efficiency gains of supplier B.

If the bargaining power is relatively small, $\beta_B < \hat{\beta}_B$, the menu of market-share contracts between dominant supplier A and downstream firm R would in contrast improve supplier B's efficiency gains.

The proof is delegated to the appendix.

Note that the results represented in proposition 3.1 stem from the impact of learning-by-doing on the payoffs. In the industry profit maximum, the effect of learning-by-doing of the dominant supplier and the rival on overall payoff is characterized by

$$\frac{\partial \pi_2^I}{\partial c_{A2}} = -q^I_{A2}(c_{A2}, c_{B2}) < 0 \text{ , and } \frac{\partial \pi_2^I}{\partial c_{B2}} = -q^I_{B2}(c_{A2}, c_{B2}) < 0.$$

That is, the more marginal costs decrease by learning-by-doing, the more do industry profits increase. Following from second period payoffs given by $\pi^*_{R2}(c_{A2}, c_{B2})$ and $\pi^*_{A2}(c_{A2}, c_{B2})$, the impact of learning-by-doing on the payoff of supplier A and downstream firm R is

$$\begin{aligned}
\frac{\partial \pi^*_{R2}}{\partial c_{A2}} &= -\beta_A q^I_{A2}(c_{A2}, c_{B2}) < 0,\\
\frac{\partial \pi^*_{R2}}{\partial c_{B2}} &= -q^I_{B2}(c_{A2}, c_{B2}) - (1-\beta_A)(\beta_B q^o_{B2}(c_{B2}) - q^I_{B2}(c_{A2}, c_{B2})) < 0,\\
\frac{\partial \pi^*_{A2}}{\partial c_{A2}} &= -(1-\beta_A) q^I_{A2}(c_{A2}, c_{B2}) < 0,\\
\frac{\partial \pi^*_{A2}}{\partial c_{B2}} &= (1-\beta_A)(\beta_B q^o_{B2}(c_{B2}) - q^I_{B2}(c_{A2}, c_{B2})).
\end{aligned}$$

If the buyer power vis-à-vis the dominant supplier equals one, the downstream firm maximizes industry profits, independent of the contract type. More interestingly and more logically for a dominant supplier, we henceforth assume that the buyer power is smaller than one, $\beta_A \lneq 1$. Then, the impact of learning of supplier A's good on the payoff of downstream firm R is lower than the impact on industry payoffs. In contrast, the impact of learning-by-doing of B on R's payoff can be the same as for industry payoffs. In particular, this is the case for $\beta_B = \hat{\beta}_B$ with $\hat{\beta}_B q^o_{B2}(c_{B2}) = q^I_{B2}(c_{A2}, c_{B2})$.[14] In this case, the downstream firm (and the rival supplier) considers the impact of learning-by-doing of B's good that maximizes industry profits. The simple two-part tariffs of the dominant supplier then achieve the industry-profit maximizing outcome because the externality due to the impact of learning of B's good on A's payoff ($\frac{\partial \pi^*_{A2}}{\partial c_{B2}}$) drops out. If instead $\beta_B > \hat{\beta}_B$, R will support the product of supplier B more powerfully than desired from an industry-profit point of view. The reason for these differences between R's quantity choice and the industry-profit maximizing one stems from the outside option $\Pi_R^{(B)}$ and in this connection from the bargaining power of R vis-à-vis the rival supplier. As there is no impact of learning on supplier B's payoff ($\pi^*_{B2} = 0$), the effects of learning-by-doing of R apply as well

[14] Note that the quantity levels $q^o_{B2}(c_{B2})$ and $q^I_{B2}(c_{A2}, c_{B2})$ depend on second-period marginal costs and these depend on first-period sales levels. For $\hat{\beta}_B$, the industry-profit maximizing quantity q^I_{B1} is equal to q^T_{B1}. That is, by inserting the industry-profit maximizing levels of marginal costs into $q^o_{B2}(c_{B2})$ and $q^I_{B2}(c_{A2}, c_{B2})$, $\hat{\beta}_B$ can easily be determined.

to cumulated payoffs of B and R. Only the dominant supplier A prefers other levels of learning effects and will influence the quantity choice of R. For supplier A, the impact of learning-by-doing of B on A's payoff is negative if $\beta_B > \hat{\beta}_B$. Hence, in case of $\beta_B > \hat{\beta}_B$, the downstream firm supports B's product in period one and the dominant supplier tries to re-balance the quantity choice of R according to industry profits. In particular, if $\beta_B > \hat{\beta}_B$, q_{B1} is too large from A's point of view. By choosing simple two-part tariffs or quantity forcing contracts, the contract menu of A and R does not fully work against the overproduction of B's good that is preferred by R. That is, if $\beta_B > \hat{\beta}_B$, the quantity level q_{B1} is larger in case of simple two-part tariffs compared to the industry profit maximum.

To the contrary, if the bargaining power of downstream firm R vis-à-vis supplier B is relatively small, $\beta_B < \hat{\beta}_B$, the effects are vice versa. Due to the small buyer power, the downstream firm prefers a level of q_{B1} that is smaller than the level which is preferable regarding industry profits. Simple two-part tariffs and quantity forcing contracts offered by the dominant supplier A cannot balance the underproduction of B's good in period one, induced by the quantity choice (in stage 3) of the downstream firm. That is, if $\beta_B < \hat{\beta}_B$, quantity q^T_{B1} is smaller than q^I_{B1}.

Furthermore, proposition 3.1 implicates that a ban on market-share contracts will enhance the efficiency of a rival supplier if the buyer power vis-à-vis the rival supplier is relatively large. Yet, a ban on market-share contracts restricts the efficiency gains of the rival supplier whenever R's bargaining power vis-à-vis the second supplier is relatively small. In the worst case then, a ban on market-share contracts could exclude the rival supplier.[15]

Market-share contracts are often suspected to be used as a price-based exclusionary or generally anticompetitive conduct.[16] In the Guidance Paper (2009), the European Commission states that it normally intervenes only if competition with as-efficient competitors is dampened. In addition, in case of network or learning effects less-efficient competitors should be taken into account as the efficiency growth of the competitor tends to be hindered by the anticompetitive conduct

[15] Note that under assumption 3.1, market-share contracts (solving for the industry-profit maximizing outcome) do not lead to exclusion of the rival supplier.

[16] Loyalty discounts, for example market-share contracts, have allegedly anticompetitive effects, see for example Economides (2009), DeGraba (2013), Greenlee and Reitman (2005).

of the dominant supplier.[17] However, the comparison of market-share contracts used by a dominant supplier and the case without the possibility of this contract offer shows that market-share contracts can improve the efficiency of the rival supplier, if buyer power is relatively low. Thus, it could happen that a less-efficient competitor is considered in the legal analysis, though the competitor would have been even lesser efficient in the absence of the abusive practice. In the worst case, the competitor could have been inactive in the market if the allegedly abusive behavior had been forbidden. In this context, our analysis shows that, in a dynamic view, further market characteristics such as the bargaining situation should be taken into consideration.

In a next step, we analyze the impact of the contract choice on social welfare. In the generally analyzed setting, it is possible to compare the quantity level of supplier B q_{B1} for specific contract types, but it is not feasible to make a general statement about aggregate sales and therefore about consumer surplus and social welfare. Thus, we specify the demand system and numerically analyze social welfare consequences.[18]

In the following, we assume that the inverse demand system is given by

$$P_A(q_{At}, q_{Bt}) = 1 - q_{At} - \gamma q_{Bt},$$
$$P_B(q_{At}, q_{Bt}) = 1 - q_{Bt} - \gamma q_{At}.$$

The (time-)discount factor δ is assumed to be one. That is, we suppose that the second-period payoffs have a strong influence on the present value of long-run profits.

Corollary 3.2 (Social welfare consequences).
When suppliers face learning-by-doing effects, a comparison of consumer surplus and social welfare can be only numerically analyzed.

For $\beta_B < \hat{\beta}_B$ ($\beta_B > \hat{\beta}_B$) consumer surplus and social welfare are larger (smaller) in case of market-share contracts than without.

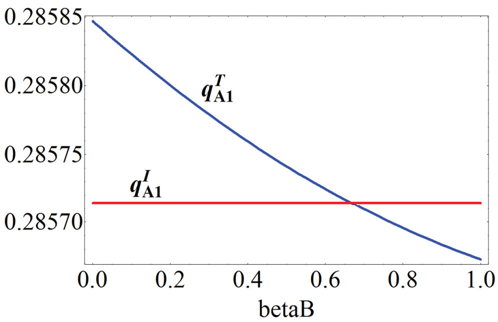
Additionally, it can numerically be shown that the larger the learning parameter,

[17]See paragraph 23 and 24, Guidance Paper (2009).

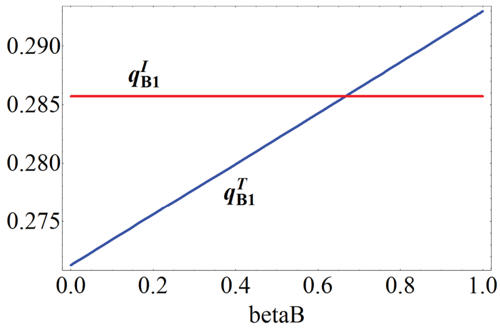
[18]A linear demand system facilitates determining quantities, consumer surplus and social welfare depending on the exogenous parameters. Though a comparison of these values can only be numerically solved.

the larger is the overall quantity and therefore the higher the consumer surplus and social welfare.

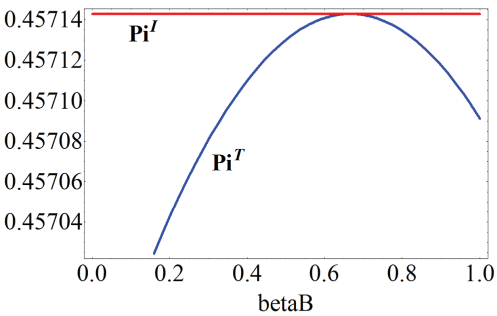
As a numerical example, figure 3.3 illustrates quantity levels, industry profits and social welfare for the parameter constellation $\beta_A = 0.5$, $c_A = 0.2$, $c_B = 0.2$, $\lambda = 0.2$, $\gamma = 0.5$. Note that in this case, $\hat{\beta}_B$ is $0.\overline{6}$.



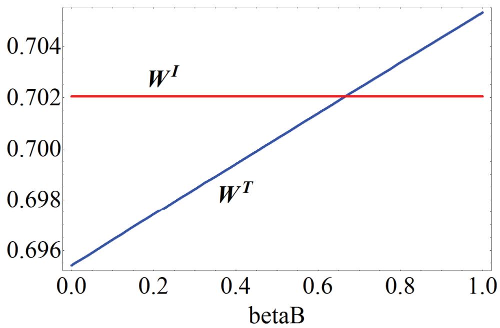
(a) Quantity level q_{A1}.



(b) Quantity level q_{B1}.



(c) Long-run joint profits.



(d) Social welfare.

Figure 3.3: Quantities, industry profits and social welfare in case of $\lambda = 0.2$, $\gamma = 0.5$, $c_A = c_B = 0.2$, and $\beta_A = 0.5$.

These findings show that not only the efficiency of the rival is restricted or enhanced in case of a specific level of buyer power, but also social welfare and consumer surplus. Hence in the present setting market-share contracts have an anticompetitive effect only if the buyer power vis-à-vis the rival supplier is relatively large. And if buyer power β_B is relatively small, market-share contracts are rather pro-competitive as they support the rival supplier and lead to a larger amount of consumer surplus and social welfare.

3.4 Modified structure of negotiations

For the structure of negotiations, we assumed that supplier A is the first negotiating supplier, not only in period one but also in period two. However, in our two-period sequential contracting framework it could also occur that the dominant position of supplier A gets lost and supplier B negotiates first in period two.

Further, there are at least two potential scenarios of renegotiations: renegotiations from status quo and renegotiations from scratch.[19] If the suppliers can renegotiate from status quo, the final outcome does not change in our sequential contracting setting. That is, the basic model actually covers the case of renegotiations from status quo. Allowing for renegotiations from scratch however means that the dominant supplier can renegotiate its contract if the negotiation of the rival supplier and downstream firm failed. Following Bedre-Defolie (2012), renegotiations from scratch may change the outside options of the firms and may therefore lead to a different result.

In the next subsections, we study these variations of our basic model.

3.4.1 Order of negotiations

Here, we suppose that the timing of the second period changes. Supplier A is the dominant firm in period one and after learning occurs, supplier B has a strategic advantage in period two.

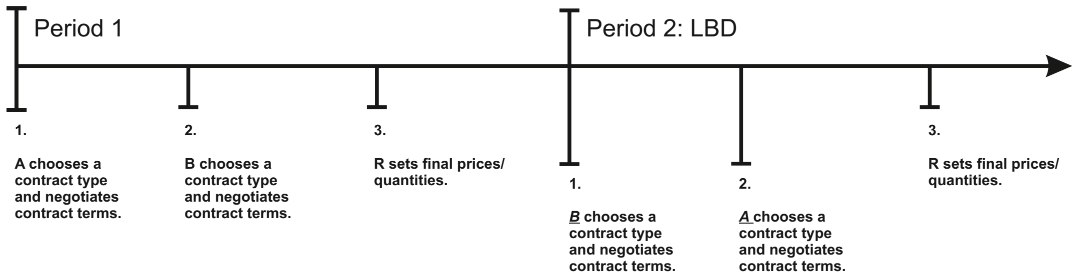


Figure 3.4: Modified timing of the two-period sequential contracting game.

Solving the model by backwards induction, the second-period outcome is analogously determined as in the basic model. The quantities equal the industry-payoff

[19] See for example Stole and Zwiebel (1996), de Fontenay and Gans (2005, 2014).

maximizing levels and second-period payoffs are given by

$$\begin{aligned}
\pi^{**}_{A2} &= 0,\\
\pi^{**}_{B2} &= (1-\beta_B)\pi^{I}_2(c_{A2}, c_{B2}) - (1-\beta_B)\beta_A \pi^{(A)}_2(c_{A2}),\\
\pi^{**}_{R2} &= \beta_B \pi^{I}_2(c_{A2}, c_{B2}) + (1-\beta_B)\beta_A \pi^{(A)}_2(c_{A2}),
\end{aligned}$$

where $\pi^{(A)}_2(c_{A2}) = \max(P_A(q_{A2}, 0) - c_{A2})q_{A2}$.
In the first period, the modified second-period payoffs are considered.[20] Here, the impact of learning of supplier B on supplier A's payoff disappears. The reason is that in the second period, payoffs are determined by a rent-shifting effect of supplier B and downstream firm R. Thus, supplier A would theoretically earn zero payoffs in the second period. Yet, a new externality appears due to the impact of learning of supplier A on supplier B's payoff ($\frac{\partial \pi^{**}_{B2}}{\partial c_{A2}} \neq 0$). The new distortion leads to the following findings.

Proposition 3.3 (Order of negotiations)**.**
If the order of negotiations changes in the second period, that is if supplier B firstly negotiates with the downstream firm in period two, simple two-part tariffs lead to the first-period outcome $q^{T'}_{A1}$, $q^{T'}_{B1}$ characterized by

$$\begin{aligned}
&\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{A2}} + \delta\lambda \frac{\partial \pi^*_{B2}}{\partial c_{A2}} \kappa_1 \kappa_2 = 0,\\
&\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} - \delta\lambda \frac{\partial \pi^*_{B2}}{\partial c_{A2}} \kappa_2 = 0,\\
&\quad \textit{where } \kappa_1 = \frac{\partial q_{B1}(w^c_{A1}, w^T_{B1})/\partial w^c_{A1}}{\partial q_{A1}(w^c_{A1}, w^T_{B1})/\partial w^c_{A1}}, \kappa_2 = \frac{\partial q_{A1}(w^c_{A1}, w_{B1})/\partial w_{B1}}{\partial q_{B1}(w^c_{A1}, w_{B1})/\partial w_{B1}},
\end{aligned}$$

determined in section 3.6. If however supplier A offers a quantity forcing contract or a market-share contract, the outcome equals the industry-profit maximizing one.

In case of simple two-part tariffs, the first-period outcome differs from the industry-profit maximizing outcome due to the impact of A's learning effects on the payoff of supplier B. In contrast to the basic model, a simple two-part tariff between B and R in period one does not achieve the cumulated payoff maximizing outcome of B and R. The externality caused by learning effects and the quantity

[20]The detailed calculations are implemented in the calculations of sections 3.3.2.1 - 3.3.2.3 of the appendix where we generally carry along the second period-payoffs of all firms.

choice of the downstream firm already appears in the negotiation between supplier B and downstream firm R. As before, a wholesale price and a fixed fee are not sufficient to perfectly influence the quantity decision of the downstream firm. Here, the reason is the impact of A's learning effect on R's payoff ($\frac{\partial \pi^{**}_{R2}}{\partial c_{A2}}$).

In case of quantity forcing or market-share contracts, the downstream firm only considers the quantity of supplier B in its quantity decision. The quantity of supplier A is already set in the first negotiation. Therefore, the negotiation of supplier B and downstream firm R leads to the outcome that maximizes their cumulated payoffs. As there is no impact of learning on the payoffs of supplier A, a quantity forcing contract as well as a market-share contract of supplier A and downstream firm R leads to the industry-payoff maximizing outcome. That is, if the order of negotiations changes, supplier A would be indifferent between offering a quantity forcing contract or a market-share contract in period one. Hence, in equilibrium, supplier A negotiates a quantity forcing contract in period one, supplier B negotiates a simple two-part tariff and downstream firm R chooses q^I_{B1}, supplier A negotiates simple two-part tariffs in period two, supplier B negotiates a simple two-part tariff and the downstream firm chooses $q^I_{A2}(c^I_{A1}, c^I_{B1})$, $q^I_{B2}(c^I_{A1}, c^I_{B1})$.

Additionally, we can show that the contract choice of supplier B has no influence on the final outcome as long as the dominant supplier offers a quantity forcing contract or a market-share contract in period one. In this context, the result equals the findings of the basic model. If however the use of quantity forcing contracts and market-share contracts by a dominant supplier was forbidden, supplier B would have an incentive to offer a market-share contract and this contract type would influence the final outcome. Namely, a market-share contract by supplier B achieves the cumulated payoff maximizing outcome in the second stage of the first-period game.

Comparing the outcome initiated by quantity forcing contracts or market-share contracts with the outcome when these contract types were forbidden, we find that the efficiency gains of supplier B and welfare can be restricted or enhanced by the additional contractual conditions. Here, the level of efficiency gains depends on the bargaining power of downstream firm R vis-à-vis supplier A. The reason is that the second-period outcome depends on the outside option of downstream firm R when dealing with supplier B, namely $\beta_A \pi_2^{(A)}$. Note that in the basic model, the outside option of downstream firm R when dealing with supplier A ($\beta_B \pi_2^{(B)}$) is crucial.

It is also possible to conceive that the second-period order of negotiations cannot be observed in the first period. In this case, the firms would have to estimate the probability for being the first or second supplier in period two. The outcome will be between the mentioned cases; depending on the distribution either closer to the basic model or to the present modification.

3.4.2 Renegotiating from scratch

Here, we suppose that if the dominant supplier and the downstream firm negotiated a contract menu, but negotiations between the second upstream firm and the downstream firm failed, the dominant supplier and downstream firm R renegotiate from scratch, similar to Bedre-Defolie (2012).

Consequently, the timing of the single-period game contains an additional stage. After the first two stages of negotiation, a third stage of bargaining appears whenever the negotiation of supplier A and downstream firm R is successful and the negotiation of supplier B and downstream firm R fails. In stage three, supplier A and downstream firm R decide about a new contract consisting of (at least) w^r_{At}, F^r_{At}. In stage four, the downstream firm finally decides about quantities and prices.

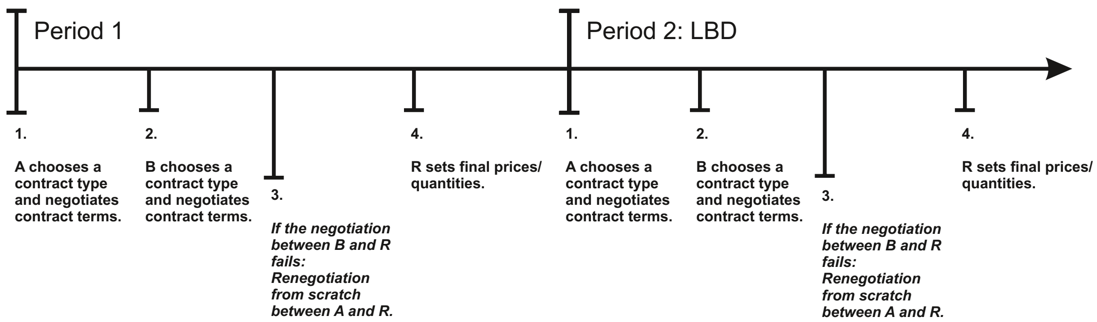


Figure 3.5: Modified timing, allowing for renegotiation from scratch.

In comparison to the previous analyses, the new stage of the dynamic game leads to a change in outside options. In particular, when the second supplier negotiates with the downstream firm, it is aware that if its negotiation with downstream firm R fails, R negotiates with the first supplier, again. This means, the outside option in the negotiation stage of the second supplier does not depend on the contents of first-stage negotiations. Rather, the outside option is constant at this point. The final outcome does not rely on the fact whether the first supplier chooses a menu of contracts or a single contract offer. In particular, the specification of an exclusive contract in a contract menu has no influence on the final outcome because contracts can be renegotiated.

Furthermore, this means that the quantity levels in the single-period game are equal to the ones determined above. Yet, the distribution of industry payoffs changes due to the modified outside options. The detailed determination of quantities is noted in section 3.6.1. The determination of payoffs is noted in section 3.6.2.

In comparison to the previous cases, both suppliers can earn positive payoffs in the single-period analysis. This fact however leads to a change in quantity levels in the two-stage game with learning effects. The impact of learning-by-doing can change payoffs of both upstream suppliers. Therefore, the first-period quantity choice is modified and will lead to a different outcome.

First, suppose that both suppliers offer simple two-part tariffs in both periods. Then, the quantity decision of the downstream firm (stage four) is similar to the case before. The outcome in the negotiation with supplier B however differs. If the second-period payoff of supplier B is positive, $\pi^{*r}_{B2} > 0$, there is an impact of learning-by-doing on the long-run payoff of the second supplier. That is, similar to the first-stage decision of the dominant supplier and downstream firm R in section 3.3.2.1, the rival supplier faces an externality due to the impact of learning (of the dominant supplier's good) on its payoff in the negotiation with downstream firm R. A simple two-part tariff between B and R cannot perfectly influence the quantity choice of the downstream firm. Therefore, the outcome in stage two of the first-period game does not equal the cumulated payoff maximizing outcome if both goods are purchased. This leads to an additional distortion from the industry profit maximizing outcome.

Second, if the dominant supplier offers a quantity forcing contract, the quantity q_{A1} would be negotiated in stage one of the first period. The downstream firm would thus only consider the quantity of the second supplier and therefore only the learning effects for the good of the rival supplier. That is, the externality of the rival supplier due to the impact of learning of supplier A on the rival's payoff is dampened in the negotiation of supplier B and downstream firm R. The outcome in case of quantity-forcing contracts can therefore be more profitable for the firms than simple two-part tariffs.

Third, if the dominant supplier uses a market-share contract, the industry profit maximizing outcome and therefore maximum payoffs are achieved, due to the same reasons as explained in the main section of the analysis. That is, in equilibrium, the dominant supplier negotiates market-share contracts in period one, the rival supplier B negotiates a simple two-part tariff and the downstream firm chooses q^I_{A1}, q^I_{B1} in period one, supplier A negotiates simple two-part tariffs in period two, supplier B negotiates a simple two-part tariff and the downstream firm chooses $q^I_{A2}(c^I_{A1}, c^I_{B1})$, $q^I_{B2}(c^I_{A1}, c^I_{B1})$.

In this context, note that a particularly high level of efficiency gains is not necessarily favored by the rival supplier. The industry profit maximizing outcome leads to maximum payoffs for all firms because the distribution of payoffs does not depend on the final outcome. The distribution only depends on bargaining power and the (constant) outside options. Therefore, the rival supplier would itself prefer smaller efficiency gains than the ones caused by the downstream firm's extensive purchases, if $\pi^{**}_{B2} \gneq 0$.

A numerical analysis with a linear demand system leads to similar results as before. The stronger a contract restricts the efficiency gain, the larger is producer surplus but the lower is consumer surplus and social welfare. In this context, market-share contracts used by the dominant supplier partially exclude the rival supplier and have a stronger anticompetitive effect than quantity forcing contracts or market-share contracts of a rival supplier.

3.5 Conclusion

This essay analyzes the contractual decision of two upstream suppliers that sequentially negotiate with a single downstream firm. Firms can choose between (menus of) simple two-part tariffs, quantity forcing contracts and market-share contracts. Considering learning-by-doing effects of the suppliers, we model two periods in which the firms sequentially negotiate.

In contrast to the single-period context without learning-by-doing, simple two-part tariffs do not suffice to implement the industry-profit maximizing outcome if learning effects occur. The deviation from this outcome stems from the fact that the firms only consider the effects of learning on their own long-run payoffs. In particular, when the downstream firm chooses first-period quantities, it considers only own payoffs. Due to this reason, wholesale prices equal to marginal costs do not yield the industry profit maximum, in general. Simple two-part tariffs offer a single instrument, namely the wholesale price, that influences the quantity choice of the downstream firm. Yet, this instrument does not suffice to fully reach the industry profit maximizing outcome. The wholesale price does not influence both quantity levels as desired by the producers.

Therefore, the suppliers have an incentive to specify further contractual terms in their negotiations with the downstream firm. We show that the dominant, first supplier prefers to offer a menu of market-share contracts. In these contracts, a relative purchase level is set besides the fixed fee and the wholesale price. Market-share contracts solve for maximum industry profits because the wholesale price and market-share level both have an influence on the quantity levels that are consumed by the downstream firm.

Our model provides new insights about the effects of a dominant firm's market-share contracts on rival suppliers and social welfare. Depending on the negotiating structure of our sequential bargaining model, the market-share contract can restrict efficiency gains of the rival supplier. Respectively, market-share contracts can lead to partial exclusion of the rival supplier and, in this case, harm consumers as well as welfare. If renegotiations are infeasible and the order of negotiations is constant, market-share contracts can also enhance the efficiency gains of the rival supplier if the rival's bargaining power is relatively large. In this case, the market-share contract of the dominant supplier enhances consumer surplus and welfare.

However, independent of the negotiating structure, the rival supplier is restricted in its contract choice as long as the dominant supplier can use contract specifications. By this means, our model rather demonstrates the inefficacy of a rival's contract choice when a dominant supplier negotiated a market-share contract, or at least a quantity forcing contract with the downstream firm. The result is connected to the temporal advantage of the dominant supplier caused by the sequential set-up. In a next step, it is interesting to allow for simultaneous moves of the competing upstream firms.

3.6 Appendix

3.6.1 Calculations of section 3.3.2

In the following calculations of section 3.3.2, we denote second-period payoffs as π^*_{J2} and determine the findings commensurately. The advantage of the generalized presentation is that the final outcome, namely the quantity levels, in case of further negotiating designs (section 3.4) are presented as well.

In the following calculations, we simplified the notation of marginal costs. Denote $c_{J2} = c_J - \lambda q_{J1}$.

Calculations of section 3.3.2.1

We solve by backwards induction. The second-period outcome is given by $q^I_{A2}(c_{A2}, c_{B2})$, $q^I_{B2}(c_{A2}, c_{B2})$. The second-period payoffs are $\pi^*_{J2}(c_{A2}, c_{B2})$ ($J \in \{A, B, R\}$). The second-period decisions are considered in period one:

Stage three

If the downstream firm purchases exclusively from supplier A, it chooses $q^o_{A1}(w^o_{A1})$, given by $\frac{\partial P_A}{\partial q_{A1}} q_{A1} + P_A(q_{A1}, 0) - w^o_{A1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} = 0$. If downstream firm R purchases only the good of supplier B, R would choose $q^o_{B2}(w_{B2})$ according to $\frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(0, q_{B1}) - w_{B1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0$. If R decides to purchase both goods, it chooses $q_{A1}(w^c_{A1}, w_{B1})$, $q_{B1}(w^c_{A1}, w_{B1})$ according to

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - w^c_{A1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} = 0, \tag{3.8}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - w_{B1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0. \tag{3.9}$$

Stage two

If supplier B and downstream firm R deal exclusively, the optimization problem is given by

$$\max_{w_{B1}, F_{B1}} (\Pi^{(B)}_R(w_{B1}, F_{B1}) - 0)^{\beta_B} \cdot (\Pi^{(B)}_B(w_{B1}, F_{B1}) - 0)^{1-\beta_B}$$
$$\Leftrightarrow \left((P_B(0, q^o_{B1}(w_{B1})) - w_{B1}) q^o_{B1}(w_{B1}) - F_{B1} + \delta\pi^*_{R2}(c_A, c_{B2})\right)^{\beta_B}$$
$$\cdot \left(q^o_{B1}(w_{B1}) \cdot (w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_A, c_{B2})\right)^{1-\beta_B}.$$

The first-order conditions that characterize w_{B1} and F_{B1} are

$$\frac{-\beta_B}{\Pi_R^{(B)}(w_{B1}, F_{B1})} + \frac{1-\beta_B}{\Pi_B^{(B)}(w_{B1}, F_{B1})} = 0,$$

$$\frac{-\beta_B q^o_{B1}(w_{B1})}{\Pi_R^{(B)}(w_{B1}, F_{B1})} + \frac{(1-\beta_B)(q^o_{B1}(w_{B1}) + (w_{B1} - c_B - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}})\frac{\partial q^o_{B1}}{\partial w_{B1}})}{\Pi_B^{(B)}(w_{B1}, F_{B1})} = 0.$$

w^T_{B1}, F^T_{B1} are thus characterized by $w_{B1} = c_B + \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}}$, and
$(1-\beta_B)\Pi_R^{(B)}(w_{B1}, F_{B1}) = \beta_B \Pi_B^{(B)}(w_{B1}, F_{B1})$.
q^o_{B1} is given by $\frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(0, q_{B1}) - c_B - \delta\lambda(\frac{\partial \pi^*_{R2}}{\partial c_{B2}} + \frac{\partial \pi^*_{B2}}{\partial c_{B2}}|_{w^T_{B1}}) = 0$. Note that if $\pi^*_{B2} = 0$, q^o_{B1} maximizes the long run joint payoff of B and R. Payoffs are given by

$$\Pi_R^{(B)} = \beta_B \Pi^{(B)},\ \Pi_B^{(B)} = (1-\beta_B)\Pi^{(B)},$$

where $\Pi^{(B)} = (P_B(0, q^o_{B1}) - c_B)q^o_{B1} + \delta\pi^*_{R2}(c_A, c_{B2}) + \delta\pi^*_{B2}(c_A, c_{B2})$ and $c_{B2} = c_B - \lambda q^o_{B1} (> 0)$.

If supplier A and downstream firm R negotiate a menu of contracts in stage one, supplier B and firm R optimize

$$\max_{w_{B1}, F_{B1}} \left(\Pi_R(w^c_{A1}, F^c_{A1}, w_{B1}, F_{B1}) - \Pi_R^{(A)}(w^o_{A1}, F^o_{A1})\right)^{\beta_B} \cdot \left(\Pi_B(w^c_{A1}, w_{B1}, F_{B1}) - 0\right)^{1-\beta_B},$$

where

$$\Pi_R(w^c_{A1}, F^c_{A1}, w_{B1}, F_{B1}) = (P_A(q_{A1}(w^c_{A1}, w_{B1}), q_{B1}(w^c_{A1}, w_{B1})) - w^c_{A1})q_{A1}(w^c_{A1}, w_{B1})$$
$$+ (P_B(q_{A1}(w^c_{A1}, w_{B1}), q_{B1}(w^c_{A1}, w_{B1})) - w_{B1})q_{B1}(w^c_{A1}, w_{B1}) - F^c_{A1} - F_{B1} + \delta\pi^*_{R2}(c_{A2}, c_{B2})$$

is the profit of firm R in dependence of the two-part tariffs, and

$$\Pi_B(w^c_{A1}, w_{B1}, F_{B1}) = q_{B1}(w^c_{A1}, w_{B1}) \cdot (w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2}, c_{B2})$$

is the profit of supplier B.

$$\Pi_R^{(A)}(w^o_{A1}, F^o_{A1}) = (P_A(q^o_{A1}(w^o_{A1}), 0) - w^o_{A1})q^o_{A1}(w^o_{A1}) - F^o_{A1} + \delta\pi^*_{R2}(c_{A2}, c_B)$$

is the outside option of downstream firm R.
The first-order conditions are

$$\frac{-\beta_B}{\Pi_R(w^c_{A1}, F^c_{A1}, w_{B1}, F_{B1}) - \Pi_R^{(A)}(w^c_{A1}, F^c_{A1})} + \frac{1-\beta_B}{\Pi_B(w^c_{A1}, w_{B1}, F_{B1})} = 0,$$

$$\frac{-\beta_B q_{B1}(w^c_{A1}, w_{B1})}{\Pi_R(w^c_{A1}, F^c_{A1}, w_{B1}, F_{B1}) - \Pi_R^{(A)}(w^c_{A1}, F^c_{A1})}$$
$$+ \frac{(1-\beta_B)(q_{B1}(w^c_{A1}, w_{B1}) + \frac{\partial q_{B1}}{\partial w_{B1}}(w_{B1} - c_B - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}}) - \frac{\partial q_{A1}}{\partial w_{B1}}\delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{A2}})}{\Pi_B(w^c_{A1}, w_{B1}, F_{B1})} = 0.$$

That is, the wholesale price w_{B1}^T can be characterized by
$w_{B1} = c_B + \delta\lambda \frac{\partial \pi_{B2}^*}{\partial c_{B2}} + \delta\lambda \frac{\partial \pi_{B2}^*}{\partial c_{A2}} \frac{\partial q_{A1}(w_{A1}^c, w_{B1})/\partial w_{B1}}{\partial q_{B1}(w_{A1}^c, w_{B1})/\partial w_{B1}}$.
For $\pi_{B2}^* = 0$, the wholesale price equals marginal costs c_B. Note that if the second-period payoff of supplier B is unequal to zero, the outcome will not maximize cumulated payoffs of B and R. The reason is the impact of learning of A's good on B's payoff ($\frac{\partial \pi_{B2}^*}{\partial c_{A2}}$).

Payoffs are

$$\begin{aligned}
&\Pi_R(w_{A1}^c, F_{A1}^c, w_{A1}^o, F_{A1}^o) = \beta_B \Pi_{BR}(w_{A1}^c, F_{A1}^c) + (1-\beta_B)\Pi_R^{(A)}(w_{A1}^o, F_{A1}^o),\\
&\Pi_B(w_{A1}^c, F_{A1}^c, w_{A1}^o, F_{A1}^o) = (1-\beta_B)(\Pi_{BR}(w_{A1}^c, F_{A1}^c) - \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)),\\
&\text{where } \Pi_{BR}(w_{A1}^c, F_{A1}^c) = (P_A(q_{A1}(w_{A1}^c, w_{B1}^T), q_{B1}(w_{A1}^c, w_{B1}^T)) - w_{A1}^c)q_{A1}(w_{A1}^c, w_{B1}^T)\\
&\qquad + (P_B(q_{A1}(w_{A1}^c, w_{B1}^T), q_{B1}(w_{A1}^c, w_{B1}^T)) - c_B)q_{B1}(w_{A1}^c, w_{B1}^T) - F_{A1}^c\\
&\qquad + \delta\pi_{R2}^*(c_{A2}, c_{B2}) + \delta\pi_{B2}^*(c_{A2}, c_{B2})
\end{aligned}$$

Stage one

The optimization problem of supplier A and downstream firm R is given by

$$\begin{aligned}
\max_{w_{A1}^o, w_{A1}^c, F_{A1}^o, F_{A1}^c} &\left(\Pi_R(w_{A1}^c, F_{A1}^c, w_{A1}^o, F_{A1}^o) - \Pi_R^{(B)}\right)^{\beta_A}\\
&\cdot \left(q_{A1}(w_{A1}^c, w_{B1}^T)\cdot(w_{A1}^c - c_A) + F_{A1}^c + \delta\pi_{A2}^*(c_{A2}, c_{B2})\right)^{1-\beta_A}\\
&\text{s.t. } \Pi_{BR}(w_{A1}^c, F_{A1}^c) \geq \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)
\end{aligned}$$

The contract menu is characterized by

$$\begin{aligned}
&(w_{A1}^{T,o}, F_{A1}^{T,o}) \text{ such that } \Pi_{BR}(w_{A1}^{T,c}, F_{A1}^{T,c}) = \Pi_R^{(A)}(w_{A1}^{T,o}, F_{A1}^{T,o}),\\
&w_{A1}^{T,c} \text{ such that}\\
&w_{A1}^c = c_A + \delta\lambda\left(\frac{\partial \pi_{A2}^*}{\partial c_{A2}} + \frac{\partial \pi_{A2}^*}{\partial c_{B2}} \frac{\partial q_{B1}(w_{A1}^c, w_{B1})/\partial w_{A1}^c}{\partial q_{A1}(w_{A1}^c, w_{B1})/\partial w_{A1}^c}\right)\\
&\qquad + \delta\lambda\frac{\partial \pi_{B2}^*}{\partial c_{A2}}\left(1 - \frac{\partial q_{A1}(w_{A1}^c, w_{B1})/\partial w_{B1}}{\partial q_{B1}(w_{A1}^c, w_{B1})/\partial w_{B1}} \cdot \frac{\partial q_{B1}(w_{A1}^c, w_{B1}^T)/\partial w_{A1}^c}{\partial q_{A1}(w_{A1}^c, w_{B1}^T)/\partial w_{A1}^c}\right)\\
&\text{and } F_{A1}^{T,c} \text{ such that}\\
&\frac{\beta_A}{\Pi_R(w_{A1}^c, F_{A1}^c, w_{A1}^o, F_{A1}^o) - \Pi_R^{(B)}} = \frac{1-\beta_A}{q_{A1}(w_{A1}^c, c_B)\cdot(w_{A1}^c - c_A) + F_{A1}^c + \delta\pi_{A2}^*(c_{A2}, c_{B2})}.
\end{aligned}$$

Inserting w_{B1}^T and $w_{A1}^{T,c}$ into the first-order conditions of the downstream firm (3.8), (3.9) yields the outcome q_{A1}^T, q_{B1}^T.

Calculations of section 3.3.2.2

We solve the models by backwards induction and especially regard the first-period calculation as the second-period outcome is clear.

a. If supplier A uses quantity forcing and supplier B uses simple two-part tariffs

In stage three, the downstream firm decides to purchase the following quantities. If R purchases only A's good, R chooses exactly the quantity which is set in the quantity forcing contract with A. (R has no decision.) If R purchases only B's good, it chooses $q^o_{B1}(w_{B1})$ according to $\frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(0, q_{B1}) - w_{B1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0$. If R purchases both goods, it chooses $q_{B1}(q^c_{A1}, w_{B1})$ according to $\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q^c_{A1}, q_{B1}) - w_{B1} - \delta\lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0$.

In stage two, if R does not negotiate with A, then B and R choose the two-part tariff analogously to the case of section 3.3.2.1. The payoffs are given by $\Pi^{(B)}_R$ and $\Pi^{(B)}_B$. If instead both goods are purchased, the optimization problem is

$$\begin{aligned}\max_{w_{B1}, F_{B1}} \; & ((P_A(q^c_{A1}, q_{B1}(q^c_{A1}, w_{B1})) - w^c_{A1})q^c_{A1} + (P_B(q^c_{A1}, q_{B1}(q^c_{A1}, w_{B1})) - w_{B1}) \\ & \cdot q_{B1}(q^c_{A1}, w_{B1}) - F^c_{A1} - F_{B1} + \delta\pi^*_{R2}(c_{A2}, c_{B2}) - \Pi^{(A)}_R(w^o_{A1}, F^o_{A1}, q^o_{A1}))^{\beta_B} \\ & \cdot (q_{B1}(q^c_{A1}, w_{B1})(w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2}, c_{B2}))^{1-\beta_B}\end{aligned}$$

where $\Pi^{(A)}_R(w^o_{A1}, F^o_{A1}, q^o_{A1}) = (P_A(q^o_{A1}, 0) - w^o_{A1})q^o_{A1} - F^o_{A1} + \delta\pi^*_{R2}(c_{A2}, c_B)$.

The negotiated wholesale price w^{QT}_{B1} is characterized by $w_{B1} = c_B + \delta\lambda \frac{\partial \pi^*_{B2}}{\partial c_{B2}}$ and F^{QT}_{B1} is given similar to the case above. Payoffs are given by

$$\Pi_R(w^c_{A1}, F^c_{A1}, q^c_{A1}, w^o_{A1}, F^o_{A1}, q^o_{A1}) = \beta_B \Pi_{BR}(w^c_{A1}, F^c_{A1}, q^c_{A1}) + (1-\beta_B)\Pi^{(A)}_R(w^o_{A1}, F^o_{A1}, q^o_{A1}),$$

$$\Pi_B(w^c_{A1}, F^c_{A1}, q^c_{A1}, w^o_{A1}, F^o_{A1}, q^o_{A1}) = (1-\beta_B)(\Pi_{BR}(w^c_{A1}, F^c_{A1}, q^c_{A1}) - \Pi^{(A)}_R(w^o_{A1}, F^o_{A1}, q^o_{A1})),$$

where $\Pi_{BR}(w^c_{A1}, F^c_{A1}, q^c_{A1}) = (P_A(q^c_{A1}, q_{B1}(q^c_{A1}, w^{QT}_{B1})) - w^c_{A1})q^c_{A1}$

$$+ (P_B(q^c_{A1}, q_{B1}(q^c_{A1}, w^{QT}_{B1})) - c_B)q_{B1}(q^c_{A1}, w^{QT}_{B1}) - F^c_{A1} + \delta\pi^*_{R2}(c_{A2}, c_{B2}) + \delta\pi^*_{B2}(c_{A2}, c_{B2})$$

In stage one, the optimization problem is

$$\begin{aligned}\max_{w^c_{A1}, w^o_{A1}, F^c_{A1}, F^o_{A1}, q^c_{A1}, q^o_{A1}} \; & \left(\Pi_R(w^c_{A1}, F^c_{A1}, q^c_{A1}, w^o_{A1}, F^o_{A1}, q^o_{A1}) - \Pi^{(B)}_R\right)^{\beta_A} \\ & \cdot \left(q^c_{A1} \cdot (w^c_{A1} - c_A) + F^c_{A1} + \delta\pi^*_{A2}(c_{A2}, c_{B2})\right)^{1-\beta_A} \\ \text{s.t. } & \Pi_{BR}(w^c_{A1}, F^c_{A1}, q^c_{A1}) \geq \Pi^{(A)}_R(w^o_{A1}, F^o_{A1}, q^o_{A1})\end{aligned}$$

Again, w^o_{A1}, F^o_{A1}, q^o_{A1} are set such that

$$\Pi_{BR}(w^c_{A1}, F^c_{A1}, q^c_{A1}) = \Pi^{(A)}_R(w^o_{A1}, F^o_{A1}, q^o_{A1}).$$

$w^{QT,c}_{A1}$ and $F^{QT,c}_{A1}$ are both given by

$$\frac{\beta_A\beta_B}{\Pi_R(w^c_{A1}, F^c_{A1}, q^c_{A1}, w^o_{A1}, F^o_{A1}, q^o_{A1}) - \Pi^{(B)}_R} = \frac{1-\beta_A}{q^c_{A1}\cdot(w^c_{A1} - c_A) + F^c_{A1} + \delta\pi^*_{A2}(c_{A2}, c_{B2})}.$$

Both serve to shift rents. $q^{QT,c}_{A1}$ is characterized by

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q^c_{A1}, q_{B1}(q^c_{A1}, w^{QT}_{B1})) - c_A - \delta\lambda\frac{\partial \pi^I_2}{\partial c_{A2}}$$
$$- \delta\lambda\frac{\partial \pi^*_{A2}}{\partial c_{B2}}\frac{\partial q_{B1}(q_{A1}, w^{QT}_{B1})}{\partial q_{A1}} = 0.$$

Generally, the outcome q^{QT}_{A1}, q^{QT}_{B1} is characterized by

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \delta\lambda\frac{\partial \pi^I_2}{\partial c_{A2}} - \delta\lambda\frac{\partial \pi^*_{A2}}{\partial c_{B2}}\frac{\partial q_{B1}(q^c_{A1}, w^{QT}_{B1})}{\partial q^c_{A1}} = 0, \tag{3.10}$$

$$\frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{B2}} - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}}\Big|_{\{w^{QT}_{B1}\}} = 0. \tag{3.11}$$

b. If supplier A uses simple two-part tariffs and supplier B uses quantity forcing

In stage three, R only decides about A's good as q_{B1} is fixed in the negotiation with B. If R purchases only A's good, it chooses $q^o_{A1}(w^o_{A1})$ according to $\frac{\partial P_A}{\partial q_{A1}}q_{A1} + P_A(q_{A1}, 0) - w^o_{A1} - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{A2}} = 0$. If R purchases both goods, it chooses $q_{A1}(w^c_{A1}, q_{B1})$ according to $\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1}, q_{B1}) - w^c_{A1} - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{A2}} = 0$. If only B and R negotiate, the quantity q^o_{B1} maximizes joint profits of B and R, because the firms jointly negotiate the quantity level. This result holds even if $\pi^*_{B2} \neq 0$ and if $\frac{\partial \pi^*_{B2}}{\partial c_{A2}}$ depends on w_{B1}. If both suppliers negotiate, the optimization problem of B and R in stage two is

$$\max_{w_{B1}, F_{B1}, q_{B1}} \Big((P_A(q_{A1}(w^c_{A1}, q_{B1}), q_{B1}) - w^c_{A1})q_{A1}(w^c_{A1}, q_{B1}) + \big(P_B(q_{A1}(w^c_{A1}, q_{B1}), q_{B1})$$
$$-w_{B1}\big)\, q_{B1} - F^c_{A1} - F_{B1} + \delta\pi^*_{R2}(c_{A2}, c_{B2}) - \Pi^{(A)}_R(w^o_{A1}, F^o_{A1})\Big)^{\beta_B}$$
$$\cdot\,(q_{B1}\cdot(w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2}, c_{B2}))^{1-\beta_B}$$

As a result, B and R set $q^{TQ}_{B1}(w^c_{A1})$ such that

$$\frac{\partial P_A}{\partial q_{B1}}q_{A1}(w^c_{A1}, q_{B1}) + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(q_{A1}(w^c_{A1}, q_{B1}), q_{B1}) - c_B$$
$$- \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{B2}} - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}} - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{A2}}\frac{\partial q_{A1}(w^c_{A1}, q_{B1})}{\partial q_{B1}} = 0$$

w^{TQ}_{B1} and F^{TQ}_{B1} are such that

$$\begin{aligned}(1-\beta_B)\cdot((&P_A(q_{A1}(w^c_{A1},q_{B1}),q_{B1})-w^c_{A1})q_{A1}(w^c_{A1},q_{B1})\\&+(P_B(q_{A1}(w^c_{A1},q_{B1}),q_{B1})-w_{B1})q_{B1}\\&-F^c_{A1}-F_{B1}+\delta\pi^*_{R2}(c_{A2},c_{B2})-\Pi^{(A)}_R(w^o_{A1},F^o_{A1}))\\&=\beta_B\cdot(q_{B1}\cdot(w_{B1}-c_B)+F_{B1}+\delta\pi^*_{B2}(c_{A2},c_{B2})).\end{aligned}$$

Both serve to shift rents. Payoffs are given by

$$\begin{aligned}&\Pi_R(w^c_{A1},F^c_{A1},w^o_{A1},F^o_{A1})=\beta_B\Pi_{BR}(w^c_{A1},F^c_{A1})+(1-\beta_B)\Pi^{(A)}_R(w^o_{A1},F^o_{A1}),\\&\Pi_B(w^c_{A1},F^c_{A1},w^o_{A1},F^o_{A1})=(1-\beta_B)(\Pi_{BR}(w^c_{A1},F^c_{A1})-\Pi^{(A)}_R(w^o_{A1},F^o_{A1})),\\&\text{where }\Pi_{BR}(w^c_{A1},F^c_{A1})=(P_A(q_{A1}(w^c_{A1},q_{B1}(w^c_{A1})),q_{B1}(w^c_{A1}))-w^c_{A1})q_{A1}(w^c_{A1},q_{B1}(w^c_{A1}))\\&\quad+(P_B(q_{A1}(w^c_{A1},q_{B1}(w^c_{A1})),q_{B1}(w^c_{A1}))-c_B)q_{B1}(w^c_{A1})-F^c_{A1}\\&\quad+\delta\pi^*_{R2}(c_{A2},c_{B2})+\delta\pi^*_{B2}(c_{A2},c_{B2}).\end{aligned}$$

In the first stage, A and R maximize

$$\begin{aligned}&(\Pi_R(w^c_{A1},F^c_{A1},w^o_{A1},F^o_{A1})-\Pi^{(B)}_R)^{\beta_A}\\&\quad\cdot(q_{A1}(w^c_{A1},q_{B1}(w^c_{A1}))(w^c_{A1}-c_A)+F^c_{A1}+\delta\pi^*_{A2}(c_{A2},c_{B2}))^{1-\beta_A}\end{aligned}$$

subject to $\Pi_{BR}(w^c_{A1},F^c_{A1})\geq\Pi^{(A)}_R(w^o_{A1},F^o_{A1})$.
The contract menu of A is structured in a similar way to the previous cases. The wholesale price $w^{TQ,c}_{A1}$ is characterized by

$$\begin{aligned}w^c_{A1}=c_A+\delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{A2}}+\delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{B2}}\frac{\partial q_{B1}(w^c_{A1})/\partial w^c_{A1}}{\partial q_{A1}(w^c_{A1},q_{B1}(w^c_{A1}))/\partial w^c_{A1}}+\delta\lambda\frac{\partial\pi^*_{B2}}{\partial c_{A2}}\\-\delta\lambda\frac{\partial\pi^*_{B2}}{\partial c_{A2}}\frac{\partial q_{A1}(w^c_{A1},q_{B1})/\partial q_{B1}\cdot\partial q_{B1}(w^c_{A1})/\partial w^c_{A1}}{\partial q_{A1}(w^c_{A1},q_{B1}(w^c_{A1}))/\partial w^c_{A1}}.\end{aligned}$$

The general outcome q^{TQ}_{A1}, q^{TQ}_{B1} is given by

$$\begin{aligned}&\frac{\partial P_A}{\partial q_{A1}}q_{A1}+\frac{\partial P_B}{\partial q_{A1}}q_{B1}+P_A(q_{A1},q_{B1})-c_A-\delta\lambda\frac{\partial\pi^*_{R2}}{\partial c_{A2}}-\delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{A2}}|_{w^{TQ,c}_{A1},w^{TQ}_{B1}}\\&\quad-\delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{B2}}|_{\{w^{TQ,c}_{A1},w^{TQ}_{B1}\}}\frac{\partial q_{B1}(w^c_{A1})/\partial w^c_{A1}}{\partial q_{A1}(w^c_{A1},q_{B1}(w^c_{A1}))/\partial w^c_{A1}}|_{\{w^{TQ,c}_{A1},w^{TQ}_{B1}\}}-\delta\lambda\frac{\partial\pi^*_{B2}}{\partial c_{A2}}|_{\{w^{TQ,c}_{A1},w^{TQ}_{B1}\}}\\&\quad+\delta\lambda\frac{\partial\pi^*_{B2}}{\partial c_{A2}}|_{\{w^{TQ,c}_{A1},w^{TQ}_{B1}\}}\frac{\partial q_{A1}(w^c_{A1},q_{B1})/\partial q_{B1}\cdot\partial q_{B1}(w^c_{A1})/\partial w^c_{A1}}{\partial q_{A1}(w^c_{A1},q_{B1}(w^c_{A1}))/\partial w^c_{A1}}=0 \qquad (3.12)\end{aligned}$$

$$\begin{aligned}&\frac{\partial P_A}{\partial q_{B1}}q_{A1}+\frac{\partial P_B}{\partial q_{B1}}q_{B1}+P_B(q_{A1},q_{B1})-c_B-\delta\lambda\frac{\partial\pi^*_{R2}}{\partial c_{B2}}\\&\quad-\delta\lambda\frac{\partial\pi^*_{B2}}{\partial c_{B2}}|_{w^{TQ}_{B1}}-\delta\lambda\frac{\partial\pi^*_{B2}}{\partial c_{A2}}|_{\{w^{TQ,c}_{A1}\}}\frac{\partial q_{A1}(w^c_{A1},q_{B1})}{\partial q_{B1}}|_{\{w^{TQ,c}_{A1}\}}=0 \qquad (3.13)\end{aligned}$$

c. If both suppliers use quantity forcing

There is no decision in stage three as both quantities q_{A1} and q_{B1} are set before. In stage two, B and R use the wholesale price and fixed fee to shift rents. If only B's good is purchased, the outcome and payoffs are similar to the cases before. If instead both goods are purchased, the quantity $q_{B1}(q^c_{A1})$ is given by

$$\frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{B2}} - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}} = 0.$$

The optimization problem of A and R in stage one is analog to a. Inter alia, it leads to the quantity q^c_{A1} given by

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1}, q_{B1}(q_{A1})) - c_A - \delta\lambda\frac{\partial \pi^I_2}{\partial c_{A2}} - \delta\lambda\frac{\partial \pi^*_{A2}}{\partial c_{B2}}\frac{\partial q_{B1}(q_{A1})}{\partial q_{A1}} = 0$$

The rest of the contractual terms are analog to the cases above. The final outcome q^Q_{A1}, q^Q_{B1} is characterized by

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1}, q_{B1}(q_{A1})) - c_A - \delta\lambda\frac{\partial \pi^I_2}{\partial c_{A2}} - \delta\lambda\frac{\partial \pi^*_{A2}}{\partial c_{B2}}\frac{\partial q_{B1}(q_{A1})}{\partial q_{A1}} = 0 \tag{3.14}$$

$$\frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{B2}} - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}} = 0 \tag{3.15}$$

Proof of proposition 3.1

In case that $\pi^*_{B2} = 0$, conditions (3.10), (3.11) and (3.14), (3.15) are equal. By using the implicit function theorem, we can show that $\frac{\partial q_{B1}(w^c_{A1})/\partial w^c_{A1}}{\partial q_{A1}(w^c_{A1}, q_{B1}(w^c_{A1}))/\partial w^c_{A1}}$ (see $w^{TQ,c}_{A1}$) equals $\frac{\partial q_{B1}(w^c_{A1}, w_{B1})/\partial w^c_{A1}}{\partial q_{A1}(w^c_{A1}, w_{B1})/\partial w^c_{A1}}$ (see $w^{T,c}_{A1}$). That is, (3.12), (3.13) as well as the mentioned conditions determine the outcome q^T_{A1}, q^T_{B1}. The reason lies in the fact that wholesale price $w_{B1} = c_B$ equals marginal costs and the downstream firm R as well as supplier A will thus maximize their joint payoffs only with regard to the externality of downstream firm R's quantity choice, induced by learning effects ($\frac{\partial \pi^*_{A2}}{\partial c_{B2}}$).

Note that this result drastically depends on the special case with $\pi^*_{B2} = 0$. In particular, second-period payoffs depend on second-period marginal costs, and therefore depend on first-period quantities and hence can depend on first-period wholesale prices. The comparison of the outcomes differs whenever second-period payoffs of supplier B are positive.

Calculations of section 3.3.2.3

a. If the dominant supplier offers a market-share contract

First, the dominant supplier could negotiate a market-share contract and the rival supplier could negotiate a two-part tariff. If R purchases only one good, it chooses $q^o_{A1}(w^o_{A1})$ or $q^o_{B1}(w_{B1})$ according to $\frac{\partial P_A}{\partial q_{A1}}q_{A1} + P_A(q_{A1},0) - w^o_{A1} - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{A2}} = 0$ or respectively $\frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(0,q_{B1}) - w_{B1} - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0$. If R purchases both goods, it chooses $q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1})$ and $q_{B1}(w^c_{A1},w_{B1},\rho^c_{B1}) = \frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1})$ according to

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1} + P_A(q_{A1},\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}) - w^c_{A1} - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{A2}}$$
$$\left(\frac{\partial P_A}{\partial q_{B1}}q_{A1} + \frac{\partial P_B}{\partial q_{B1}}\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1} + P_B(q_{A1},\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}) - w_{B1} - \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{B2}}\right)\frac{1-\rho^c_{A1}}{\rho^c_{A1}} = 0.$$

If only B's good is purchased, the contract of B and R leads to $\Pi^{(B)}_R$ and $\Pi^{(B)}_B$. If both goods are purchased, the optimization problem is

$$\max_{w_{B1},F_{B1}} \left(\Pi_R(w^c_{A1},F^c_{A1},\rho^c_{A1},w_{B1},F_{B1}) - \Pi^{(A)}_R(w^o_{A1},F^o_{A1})\right)^{\beta_B}$$
$$\cdot\left(\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1})(w_{B1}-c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2},c_{B2})\right)^{1-\beta_B}$$

where

$$\Pi_R(w^c_{A1},F^c_{A1},\rho^c_{A1},w_{B1},F_{B1}) = (P_A(q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1}),\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1})) - w^c_{A1})$$
$$\cdot\, q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1}) + (P_B(q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1}),\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1})) - w_{B1})$$
$$\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1}) - F^c_{A1} - F_{B1} + \delta\pi^*_{R2}(c_{A2},c_{B2})$$

and $\Pi^{(A)}_R(w^o_{A1},F^o_{A1})$ as before, because the exclusive contract implies $\rho^o_{A1} = 1$. For simplicity, we do not list ρ^o_{A1}.

The negotiated fixed fee F^{MT}_{B1} is characterized by
$\frac{\beta_B}{\Pi_R(w^c_{A1},F^c_{A1},\rho^c_{A1},w_{B1},F_{B1}) - \Pi^{(A)}_R(w^o_{A1},F^o_{A1})} = \frac{1-\beta_B}{\frac{1-\rho^c_{A1}}{\rho^c_{A1}}q_{A1}(w^c_{A1},w_{B1},\rho^c_{A1})(w_{B1}-c_B)+F_{B1}+\delta\pi^*_{B2}(c_{A2},c_{B2})}$.

The wholesale price $w^{MT}_{B1}(w^c_{A1},\rho^c_{A1})$ is given by
$w_{B1} = c_B + \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}} + \frac{\rho^c_{A1}}{1-\rho^c_{A1}}\delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{A2}}$.

The payoff of R can thus be written as

$$\Pi_R(w^c_{A1}, F^c_{A1}, \rho^c_{A1}, w^o_{A1}, F^o_{A1}) = \beta_B \Pi_{BR}(w^c_{A1}, F^c_{A1}, \rho^c_{A1}) + (1-\beta_B)\Pi_R^{(A)}(w^o_{A1}, F^o_{A1})$$

with $\Pi_{BR}(w^c_{A1}, F^c_{A1}, \rho^c_{A1}) =$

$$(P_A(q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1}), \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1})) - w^c_{A1})$$
$$\cdot q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1}) + (P_B(q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1}), \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1})) - c_B)$$
$$\cdot \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1}) - F^c_{A1} + \delta\pi^*_{R2}(c_{A2}, c_{B2}) + \delta\pi^*_{B2}(c_{A2}, c_{B2}).$$

In stage one, the optimization problem of A and R is

$$\begin{aligned} \max & \Big(\Pi_R(w^c_{A1}, F^c_{A1}, \rho^c_{A1}, w^o_{A1}, F^o_{A1}) - \Pi_R^{(B)}\Big)^{\beta_A} \\ & \cdot \big(q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1})(w^c_{A1} - c_A) + F^c_{A1} + \delta\pi^*_{A2}(c_{A2}, c_{B2})\big)^{1-\beta_A} \\ \text{s.t. } & \Pi_{BR}(w^c_{A1}, F^c_{A1}, \rho^c_{A1}) \geq \Pi_R^{(A)}(w^o_{A1}, F^o_{A1}). \end{aligned}$$

$w^{MT,o}_{A1}$, $F^{MT,o}_{A1}$ are such that
$\Pi_{BR}(w^c_{A1}, F^c_{A1}, \rho^c_{A1}) = \Pi_R^{(A)}(w^o_{A1}, F^o_{A1})$.
$F^{MT,c}_{A1}$ is such that
$\frac{\beta_A\beta_B}{\Pi_R(w^c_{A1}, F^c_{A1}, \rho^c_{A1}, w^o_{A1}, F^o_{A1}) - \Pi_R^{(B)}} = \frac{1-\beta_A}{q_{A1}(w^c_{A1}, w_{B1}, \rho^c_{A1})(w^c_{A1} - c_A) + F^c_{A1} + \delta\pi^*_{A2}(c_{A2}, c_{B2})}$.
$\rho^{MT,c}_{A1}$ and $w^{MT,c}_{A1}$ are characterized by

$$\begin{aligned} & w_{A1} = c_A + \delta\lambda \frac{\partial \pi^*_{A2}}{\partial c_{A2}} + \delta\lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{1-\rho^c_{A1}}{\rho^c_{A1}}, \\ & \frac{\partial P_A}{\partial q_{B1}} q_{A1}(w^c_{A1}, w^{MT}_{B1}, \rho^c_{A1}) + \frac{\partial P_B}{\partial q_{B1}} \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1}(w^c_{A1}, w^{MT}_{B1}, \rho^c_{A1}) \\ & \qquad + P_B(q_{A1}(w^c_{A1}, w^{MT}_{B1}, \rho^c_{A1}), \frac{1-\rho^c_{A1}}{\rho^c_{A1}} q_{A1}(w^c_{A1}, w^{MT}_{B1}, \rho^c_{A1})) - c_B - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} = 0. \end{aligned}$$

That is, the final outcome is given by

$$\begin{aligned} \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{A2}} = 0, \\ \frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda \frac{\partial \pi^I_2}{\partial c_{B2}} = 0. \end{aligned}$$

Second, the dominant supplier could negotiate a market-share contract and the second supplier could use quantity forcing. The stage three decision is omitted. If the negotiation in stage one failed, the negotiation in stage two leads to $\Pi_B^{(B)}$ and $\Pi_R^{(B)}$. If A and R negotiate a contract in stage one, B and R maximize

$$\max\left(\Pi_R(w_{A1}^c, F_{A1}^c, \rho_{A1}^c, w_{B1}, F_{B1}, q_{B1}) - \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)\right)^{\beta_B}$$
$$\cdot\,(q_{B1}(w_{B1} - c_B) + F_{B1} + \delta\pi_{B2}^*(c_{A2}, c_{B2}))^{1-\beta_B}$$

where
$\Pi_R(w_{A1}^c, F_{A1}^c, \rho_{A1}^c, w_{B1}, F_{B1}, q_{B1}) = (P_A(\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}, q_{B1}) - w_{A1}^c)\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}$
$+(P_B(\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}, q_{B1}) - w_{B1})q_{B1} - F_{A1}^c - F_{B1} + \delta\pi_{R2}^*(c_{A2}, c_{B2})$,
and $\Pi_R^{(A)}(w_{A1}^o, F_{A1}^o) = (P_A(q_{A1}^o(w_{A1}^o), 0) - w_{A1}^o)q_{A1}^o(w_{A1}^o) - F_{A1}^o + \delta\pi_{R2}^*(c_{A2}, c_B)$.
As a result, w_{B1}^{MQ} and F_{B1}^{MQ} are given by $\frac{\beta_B}{\Pi_R(w_{A1}^c, F_{A1}^c, \rho_{A1}^c, w_{B1}, F_{B1}, q_{B1}) - \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)} = \frac{1-\beta_B}{q_{B1}(w_{B1}-c_B)+F_{B1}+\delta\pi_{B2}^*(c_{A2}, c_{B2})}$.

$q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c)$ is characterized by

$$\left(\frac{\partial P_A}{\partial q_{A1}}\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}, q_{B1}) - w_{A1}^c - \delta\lambda\frac{\partial \pi_{R2}^*}{\partial c_{A2}} - \delta\lambda\frac{\partial \pi_{B2}^*}{\partial c_{A2}}\right)\frac{\rho_{A1}^c}{1-\rho_{A1}^c}$$
$$\frac{\partial P_A}{\partial q_{B1}}\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}, q_{B1}) - c_B - \delta\lambda\frac{\partial \pi_{R2}^*}{\partial c_{B2}} - \delta\lambda\frac{\partial \pi_{B2}^*}{\partial c_{B2}} = 0.$$

The payoff of R can thus be written as
$\Pi_R(w_{A1}^c, F_{A1}^c, \rho_{A1}^c, w_{A1}^o, F_{A1}^o) = \beta_B\Pi_{BR}(w_{A1}^c, F_{A1}^c, \rho_{A1}^c) + (1-\beta_B)\Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)$
with

$$\Pi_{BR}(w_{A1}^c, F_{A1}^c, \rho_{A1}^c) = (P_A(\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c), q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c)) - w_{A1}^c)$$
$$\cdot\,\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c) + (P_B(\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c), q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c)) - c_B)$$
$$\cdot\,q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c) - F_{A1}^c + \delta\pi_{R2}^*(c_{A2}, c_{B2}) + \delta\pi_{B2}^*(c_{A2}, c_{B2}).$$

In stage one, the optimization problem of A and R is

$$\max\left(\Pi_R(w_{A1}^c, F_{A1}^c, \rho_{A1}^c, w_{A1}^o, F_{A1}^o) - \Pi_R^{(B)}\right)^{\beta_A}$$
$$\cdot\left(\frac{\rho_{A1}^c}{1-\rho_{A1}^c}q_{B1}^{MQ}(w_{A1}^c, \rho_{A1}^c)(w_{A1}^c - c_A) + F_{A1}^c + \delta\pi_{A2}^*(c_{A2}, c_{B2})\right)^{1-\beta_A}$$
$$\text{s.t. } \Pi_{BR}(w_{A1}^c, F_{A1}^c, \rho_{A1}^c) \geq \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o).$$

As before, $w_{A1}^{MQ,o}$ and $F_{A1}^{MQ,o}$ are set such that $\Pi_{BR}(w_{A1}^c, F_{A1}^c, \rho_{A1}^c) = \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)$. $F_{A1}^{MQ,c}$ is set such that

$$\frac{\beta_A\beta_B}{\Pi_R(w^c_{A1},F^c_{A1},\rho^c_{A1},w^o_{A1},F^o_{A1})-\Pi_R^{(B)}} = \frac{1-\beta_A}{\frac{\rho^c_{A1}}{1-\rho^c_{A1}}q^{MQ}_{B1}(w^c_{A1},\rho^c_{A1})(w^c_{A1}-c_A)+F^c_{A1}+\delta\pi^*_{A2}(c_{A2},c_{B2})}.$$

$w^{MQ,c}_{A1}$ and $\rho^{MQ,c}_{A1}$ are characterized by

$$w^c_{A1} = c_A + \delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{A2}} + \delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{B2}}\frac{1-\rho^c_{A1}}{\rho^c_{A1}},$$

$$\frac{\partial P_A}{\partial q_{A1}}q_{A1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(q_{A1},q_{B1}) - c_A - \delta\lambda\frac{\partial\pi^I_2}{\partial c_{A2}} = 0.$$

That is, the final outcome is also equal to the joint-payoff maximizing outcome.

b. If the rival supplier offers a market-share contract

First, supplier A could negotiate two-part tariffs with downstream firm R and supplier B could negotiate a market-share contract. In stage three, the downstream firm chooses $q^o_{A1}(w^o_{A1})$ according to $\frac{\partial P_A}{\partial q_{A1}}q_{A1} + P_A(q_{A1},0) - w^o_{A1} - \delta\lambda\frac{\partial\pi^*_{R2}}{\partial c_{A2}} = 0$ if R purchases only A's good. R chooses $q^o_{B1}(w_{B1})$ according to $\frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(0,q_{B1}) - w_{B1} - \delta\lambda\frac{\partial\pi^*_{R2}}{\partial c_{B2}} = 0$ if only B's good is purchased. If both goods are bought, R chooses $q_{B1}(w^c_{A1},w_{B1},\rho_{B1})$ and $q_{A1}(w^c_{A1},w_{B1},\rho_{B1}) = \frac{1-\rho_{B1}}{\rho_{B1}}q_{B1}(w^c_{A1},w_{B1},\rho_{B1})$ according to

$$\frac{1-\rho_{B1}}{\rho_{B1}}\left(\frac{\partial P_A}{\partial q_{A1}}\frac{1-\rho_{B1}}{\rho_{B1}}q_{B1} + \frac{\partial P_B}{\partial q_{A1}}q_{B1} + P_A(\frac{1-\rho_{B1}}{\rho_{B1}}q_{B1},q_{B1}) - w^c_{A1} - \delta\lambda\frac{\partial\pi^*_{R2}}{\partial c_{A2}}\right)$$
$$+\frac{\partial P_A}{\partial q_{B1}}\frac{1-\rho_{B1}}{\rho_{B1}}q_{B1} + \frac{\partial P_B}{\partial q_{B1}}q_{B1} + P_B(\frac{1-\rho_{B1}}{\rho_{B1}}q_{B1},q_{B1}) - w_{B1} - \delta\lambda\frac{\partial\pi^*_{R2}}{\partial c_{B2}} = 0$$

In stage two, if both goods are purchased, the optimization problem of B and R is

$$\max_{w_{B1},F_{B1},\rho_{B1}} \left(\Pi_R(w^c_{A1},F^c_{A1},w_{B1},F_{B1},\rho_{B1}) - \Pi^{(A)}_R(w^o_{A1},F^o_{A1})\right)^{\beta_B}$$
$$\cdot\left(q_{B1}(w^c_{A1},w_{B1},\rho_{B1})(w_{B1}-c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2},c_{B2}) - 0\right)^{1-\beta_B}$$

where $\Pi_R(w^c_{A1},F^c_{A1},w_{B1},F_{B1},\rho_{B1})$

$$= (P_A(\frac{1-\rho_{B1}}{\rho_{B1}}q_{B1}(w^c_{A1},w_{B1},\rho_{B1}),qB1(w^c_{A1},w_{B1},\rho_{B1})) - w^c_{A1})\frac{1-\rho_{B1}}{\rho_{B1}}q_{B1}(w^c_{A1},w_{B1},\rho_{B1})$$
$$+ (P_B(\frac{1-\rho_{B1}}{\rho_{B1}}q_{B1}(w^c_{A1},w_{B1},\rho_{B1}),q_{B1}(w^c_{A1},w_{B1},\rho_{B1})) - w_{B1})q_{B1}(w^c_{A1},w_{B1},\rho_{B1})$$
$$- F^c_{A1} - F_{B1} + \delta\pi^*_{R2}(c_{A2},c_{B2})$$

and $\Pi^{(A)}_R(w^o_{A1},F^o_{A1}) = (P_A(q^o_{A1}(w^o_{A1}),0) - w^o_{A1})q^o_{A1}(w^o_{A1}) - F^o_{A1} + \delta\pi^*_{R2}(c_{A2},c_B)$.

$w_{B1}^{TM}(w_{A1}^c)$ and $\rho_{B1}^{TM}(w_{A1}^c)$ are characterized by

$$w_{B1} = c_B + \delta\lambda \frac{1-\rho_{B1}}{\rho_{B1}} \frac{\partial \pi_{B2}^*}{\partial c_{A2}} + \delta\lambda \frac{\partial \pi_{B2}^*}{\partial c_{B2}},$$

$$\frac{\partial P_A}{\partial q_{A1}} \frac{1-\rho_{B1}}{\rho_{B1}} q_{B1}(w_{A1}^c, w_{B1}, \rho_{B1}) + \frac{\partial P_B}{\partial q_{A1}} q_{B1}(w_{A1}^c, w_{B1}, \rho_{B1})$$
$$+ P_A(\frac{1-\rho_{B1}}{\rho_{B1}} q_{B1}(w_{A1}^c, w_{B1}, \rho_{B1}), q_{B1}(w_{A1}^c, w_{B1}, \rho_{B1})) - w_{A1}^c - \delta\lambda \frac{\partial \pi_{R2}^*}{\partial c_{A2}} - \delta\lambda \frac{\partial \pi_{B2}^*}{\partial c_{A2}} = 0.$$

F_{B1}^{TM} is characterized by

$$\frac{\beta_B}{\Pi_R(w_{A1}^c, F_{A1}^c, w_{B1}, F_{B1}, \rho_{B1}) - \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)}$$
$$= \frac{1-\beta_B}{q_{B1}(w_{A1}^c, w_{B1}, \rho_{B1})(w_{B1} - c_B) + F_{B1} + \delta\pi_{B2}^*(c_{A2}, c_{B2})}.$$

The payoff of R is

$\Pi_R(w_{A1}^c, F_{A1}^c, w_{A1}^o, F_{A1}^o) = \beta_B \Pi_{BR}(w_{A1}^c, F_{A1}^c) + (1-\beta_B)\Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)$, where

$$\Pi_{BR}(w_{A1}^c, F_{A1}^c) = (P_A(\tfrac{1-\rho_{B1}(w_{A1}^c)}{\rho_{B1}(w_{A1}^c)} q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c)),$$
$$q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))) - w_{A1}^c) \tfrac{1-\rho_{B1}(w_{A1}^c)}{\rho_{B1}(w_{A1}^c)} q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))$$
$$+(P_B(\tfrac{1-\rho_{B1}(w_{A1}^c)}{\rho_{B1}(w_{A1}^c)} q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c)), q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c)))$$
$$-w_{B1}(w_{A1}^c))q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c)) - F_{A1}^c + \delta\pi_{R2}^*(c_{A2}, c_{B2}) + \delta\pi_{B2}^*(c_{A2}, c_{B2}).$$

In stage one, A and R optimize

$$\max \left(\Pi_R(w_{A1}^c, F_{A1}^c, w_{A1}^o, F_{A1}^o) - \Pi_R^{(B)}\right)^{\beta_A}$$
$$\cdot \left(\frac{1-\rho_{B1}(w_{A1}^c)}{\rho_{B1}(w_{A1}^c)} q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))(w_{A1}^c - c_A) + F_{A1}^c + \delta\pi_{A2}^*(c_{A2}, c_{B2})\right)^{1-\beta_A}$$

s.t. $\Pi_R(w_{A1}^c, F_{A1}^c) \geq \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)$

$w_{A1}^{TM,o}$ and $F_{A1}^{TM,o}$ are such that $\Pi_R(w_{A1}^c, F_{A1}^c) = \Pi_R^{(A)}(w_{A1}^o, F_{A1}^o)$. $w_{A1}^{TM,c}$ is characterized by

$$w_{A1}^c = c_A + \delta\lambda \frac{\partial \pi_{A2}^*}{\partial c_{A2}}$$
$$+ \delta\lambda \frac{\partial \pi_{A2}^*}{\partial c_{B2}} \frac{\partial q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))/\partial w_{A1}^c}{-\frac{q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))}{\rho_{B1}(w_{A1}^c)^2} \frac{\partial \rho_{B1}}{\partial w_{A1}^c} + \frac{1-\rho_{B1}(w_{A1}^c)}{\rho_{B1}(w_{A1}^c)} \frac{\partial q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))}{\partial w_{A1}^c}}.$$

Generally, the outcome q_{A1}^{TM}, q_{B1}^{TM} is characterized by

$$0 = \frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \delta\lambda \frac{\partial \pi_2^I}{\partial c_{A2}}$$
$$- \delta\lambda \frac{\partial \pi_{A2}^*}{\partial c_{B2}} \frac{\partial q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))/\partial w_{A1}^c}{-\frac{q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))}{\rho_{B1}(w_{A1}^c)^2} \frac{\partial \rho_{B1}}{\partial w_{A1}^c} + \frac{1-\rho_{B1}(w_{A1}^c)}{\rho_{B1}(w_{A1}^c)} \frac{\partial q_{B1}(w_{A1}^c, w_{B1}(w_{A1}^c), \rho_{B1}(w_{A1}^c))}{\partial w_{A1}^c}},$$

$$0 = \frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \delta\lambda \frac{\partial \pi_2^I}{\partial c_{B2}} + \delta\lambda \frac{\partial \pi_{A2}^*}{\partial c_{B2}}.$$

Second, supplier A could use quantity forcing contracts and supplier B could negotiate a market-share contract. In this case, stage three is omitted as the share $\rho_{B1} = \frac{q_{B1}}{q_{A1}+q_{B1}}$ and q_{A1} are set in stage one and two. In stage two, the optimization problem of B and R leads to maximum cumulated payoffs, if the negotiation of A and R in stage one failed. If A and R negotiated a contract menu in stage one, the optimization problem of B and R is

$$\max_{w_{B1},F_{B1},\rho_{B1}} \left(\Pi_R(w^c_{A1}, F^c_{A1}, q^c_{A1}, w_{B1}, F_{B1}, \rho_{B1}) - \Pi_R^{(A)}(w^o_{A1}, F^o_{A1}, q^o_{A1})\right)^{\beta_B}$$
$$\cdot \left(\frac{\rho_{B1}}{1-\rho_{B1}} q_{A1}(w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2}, c_{B2})\right)^{1-\beta_B}$$
$$\text{where } \Pi_R(w^c_{A1}, F^c_{A1}, q^c_{A1}, w_{B1}, F_{B1}, \rho_{B1}) = (P_A(q^c_{A1}, \frac{\rho_{B1}}{1-\rho_{B1}} q^c_{A1}) - w^c_{A1})q^c_{A1}$$
$$+ (P_B(q^c_{A1}, \frac{\rho_{B1}}{1-\rho_{B1}} q^c_{A1}) - w_{B1})\frac{\rho_{B1}}{1-\rho_{B1}} q^c_{A1} - F^c_{A1} - F_{B1} + \delta\pi^*_{R2}(c_{A2}, c_{B2}).$$

As a result, B and R set w^{QM}_{B1}, F^{QM}_{B1} such that

$$\frac{\beta_B}{\Pi_R(w^c_{A1}, F^c_{A1}, q^c_{A1}, w_{B1}, F_{B1}, \rho_{B1}) - \Pi_R^{(A)}(w^o_{A1}, F^o_{A1}, q^o_{A1})}$$
$$= \frac{1-\beta_B}{\frac{\rho_{B1}}{1-\rho_{B1}} q_{A1}(w_{B1} - c_B) + F_{B1} + \delta\pi^*_{B2}(c_{A2}, c_{B2})}.$$

$\rho^{QM}_{B1}(q^c_{A1})$ is characterized by

$$\frac{\partial P_A}{\partial q_{B1}} q^c_{A1} + \frac{\partial P_B}{\partial q_{B1}} \frac{\rho_{B1}(w^c_{A1})}{1-\rho_{B1}(w^c_{A1})} q^c_{A1} + P_B\left(q^c_{A1}, \frac{\rho_{B1}(w^c_{A1})}{1-\rho_{B1}(w^c_{A1})} q^c_{A1}\right) - c_B$$
$$- \delta\lambda\frac{\partial \pi^*_{R2}}{\partial c_{B2}} - \delta\lambda\frac{\partial \pi^*_{B2}}{\partial c_{B2}} = 0.$$

In conformity with the previous calculations, the payoff of B can be written as
$\Pi_R(w^c_{A1}, F^c_{A1}, q^c_{A1}, w^o_{A1}, F^o_{A1}, q^o_{A1}) = \beta_B \Pi_{BR}(w^c_{A1}, F^c_{A1}, q^c_{A1}) + (1 - \beta_B)\Pi_R^{(A)}(w^o_{A1}, F^o_{A1}, q^o_{A1})$

$$\text{where } \Pi_{BR}(w^c_{A1}, F^c_{A1}, q^c_{A1}) = \left(P_A(q^c_{A1}, \frac{\rho^{QM}_{B1}(q^c_{A1})}{1-\rho^{QM}_{B1}(q^c_{A1})} q^c_{A1}) - w^c_{A1}\right) q^c_{A1}$$
$$+ \left(P_B(q^c_{A1}, \frac{\rho^{QM}_{B1}(q^c_{A1})}{1-\rho^{QM}_{B1}(q^c_{A1})} q^c_{A1}) - w^{QM}_{B1}\right) \frac{\rho^{QM}_{B1}(q^c_{A1})}{1-\rho^{QM}_{B1}(q^c_{A1})} q^c_{A1}$$
$$- F^c_{A1} + \delta\pi^*_{R2}(c_{A2}, c_{B2}) + \delta\pi^*_{B2}(c_{A2}, c_{B2}).$$

The optimization problem of A and R in stage one is

$$\begin{aligned}
&\max\left(\Pi_R(w^c_{A1},F^c_{A1},q^c_{A1},w^o_{A1},F^o_{A1},q^o_{A1})-\Pi_R^{(B)}\right)^{\beta_A}\\
&\qquad\cdot\left(q^c_{A1}(w^c_{A1}-c_A)+F^c_{A1}+\delta\pi^*_{A2}(c_{A2},c_{B2})\right)^{1-\beta_A}\\
&\text{s.t. }\ \Pi_{BR}(w^c_{A1},F^c_{A1},q^c_{A1})\geq\Pi_R^{(A)}(w^o_{A1},F^o_{A1},q^o_{A1})
\end{aligned}$$

$w^{QM,o}_{A1}$, $F^{QM,o}_{A1}$, $q^{QM,o}_{A1}$ are such that $\Pi_{BR}(w^c_{A1},F^c_{A1},q^c_{A1})=\Pi_R^{(A)}(w^o_{A1},F^o_{A1},q^o_{A1})$. $w^{QM,c}_{A1}$ and $F^{QM,c}_{A1}$ are such that

$$\frac{\beta_A\beta_B}{\Pi_R(w^c_{A1},F^c_{A1},q^c_{A1},w^o_{A1},F^o_{A1},q^o_{A1})-\Pi_R^{(B)}}=\frac{1-\beta_A}{q^c_{A1}(w^c_{A1}-c_A)+F^c_{A1}+\delta\pi^*_{A2}(c_{A2},c_{B2})},$$

and $q^{QM,c}_{A1}$ is characterized by

$$\begin{aligned}
&\frac{\partial P_A}{\partial q_{A1}}q^c_{A1}+\frac{\partial P_B}{\partial q_{A1}}\frac{\rho_{B1}(q^c_{A1})}{1-\rho_{B1}(q^c_{A1})}q^c_{A1}+P_A(q^c_{A1},\frac{\rho^{QM}_{B1}(q^c_{A1})}{1-\rho^{QM}_{B1}(q^c_{A1})}q^c_{A1})-c_A-\delta\lambda\frac{\partial\pi^I_2}{\partial c_{A2}}\\
&\quad-\delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{B2}}\left(\frac{\rho^{QM}_{B1}(q^c_{A1})}{1-\rho^{QM}_{B1}(q^c_{A1})}+\frac{q^c_{A1}}{(1-\rho^{QM}_{B1}(q^c_{A1}))^2}\frac{\partial\rho^{QM}_{B1}(q^c_{A1})}{\partial q^c_{A1}}\right)=0.
\end{aligned}$$

Generally, the final outcome q^{QM}_{A1}, q^{QM}_{B1} is characterized by

$$\begin{aligned}
&\frac{\partial P_A}{\partial q_{A1}}q_{A1}+\frac{\partial P_B}{\partial q_{A1}}q_{B1}+P_A(q_{A1},\frac{\rho_{B1}(w_{A1})}{1-\rho_{B1}(w_{A1})}q_{A1})-c_A-\delta\lambda\frac{\partial\pi^I_2}{\partial c_{A2}}\\
&\quad-\delta\lambda\frac{\partial\pi^*_{A2}}{\partial c_{B2}}\left(\frac{\rho^{QM}_{B1}(q_{A1})}{1-\rho^{QM}_{B1}(q_{A1})}+\frac{q_{A1}}{(1-\rho^{QM}_{B1}(q_{A1}))^2}\frac{\partial\rho^{QM}_{B1}(q_{A1})}{\partial q_{A1}}\right)=0,\\
&\frac{\partial P_A}{\partial q_{B1}}q_{A1}+\frac{\partial P_B}{\partial q_{B1}}\frac{\rho_{B1}(w_{A1})}{1-\rho_{B1}(w_{A1})}q_{A1}+P_B(q_{A1},\frac{\rho_{B1}(w_{A1})}{1-\rho_{B1}(w_{A1})}q_{A1})-c_B-\delta\lambda\frac{\partial\pi^*_{R2}}{\partial c_{B2}}-\delta\lambda\frac{\partial\pi^*_{B2}}{\partial c_{B2}}=0.
\end{aligned}$$

Proof of proposition 3.2

The result of the first part is proven in the calculations of section 3.3.2.3.a.
The result of the second part of the proposition follows from the calculations of section 3.3.2.3.b, and from a comparison of the first-order conditions with the ones that solve for q^T_{A1}, q^T_{B1} - with the implicit function theorem.

Proof of corollary 3.1

Second-period payoffs are given by

$$\begin{aligned}
\pi^*_{A2}(c_{A2},c_{B2})&=(1-\beta_A)(\pi^I_2(c_{A2},c_{B2})-\beta_B\pi_2^{(B)}),\\
\pi^*_{R2}(c_{A2},c_{B2})&=\beta_A\pi^I_2(c_{A2},c_{B2})+(1-\beta_A)\beta_B\pi_2^{(B)},\\
\pi^*_{B2}(c_{A2},c_{B2})&=0.
\end{aligned}$$

The impact of learning effects of A on payoffs are given by

$$\frac{\partial \pi^*_{A2}}{\partial c_{A2}} = -(1-\beta_A)q^I_{A2} < 0, \qquad \frac{\partial \pi^*_{R2}}{\partial c_{A2}} = -\beta_A q^I_{A2} < 0.$$

The impact of learning effects of B on payoffs are

$$\frac{\partial \pi^*_{A2}}{\partial c_{B2}} = (1-\beta_A)(\beta_B q^o_{B2} - q^I_{B2}) \lesseqgtr 0, \qquad \frac{\partial \pi_{R2}}{\partial c_{B2}} = -\beta_A q^I_{B2} - (1-\beta_A)\beta_B q^o_{B2} < 0.$$

The outcome q^T_{A1}, q^T_{B1} (in the specific set-up equal to q^Q_{A1}, q^Q_{B1}) can be characterized by

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A + \delta\lambda q^I_{A2} - \delta\lambda\alpha(1-\beta_A)(\beta_B q^o_{B2} - q^I_{B2}) = 0, \tag{3.16}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B + \delta\lambda q^I_{B2} + \delta\lambda(1-\beta_A)(\beta_B q^o_{B2} - q^I_{B2}) = 0, \tag{3.17}$$

where $\alpha = -\frac{\partial q_{B1}(q_{A1})}{\partial q_{A1}}$ is positive and supposed to be smaller than one.

Define $\hat{\beta}_B$ such that $\hat{\beta}_B q^o_{B2} - q^I_{B2} = 0$. In this case, conditions (3.16), (3.17) equal the first order conditions of the joint-profit maximization. For $\beta_B q^o_{B2} > q^I_{B2}$, we compare the joint-profit maximizing outcome with the outcome of the varied system

$$\begin{aligned}
&\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A + \delta\lambda q^I_{A2} + \delta\lambda(1-\beta_A)(\beta_B q^o_{B2}|_{\{c^T_{B2}\}} - q^I_{B2}|_{\{c^T_{A2}, c^T_{B2}\}}) = 0,\\
&\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B + \delta\lambda q^I_{B2} + \delta\lambda(1-\beta_A)(\beta_B q^o_{B2}|_{\{c^T_{B2}\}} - q^I_{B2}|_{\{c^T_{A2}, c^T_{B2}\}}) = 0.
\end{aligned} \tag{var}$$

As $\delta\lambda(1-\beta_A)(\beta_B q^o_{B2}|_{\{c^T_{B2}\}} - q^I_{B2}|_{\{c^T_{A2}, c^T_{B2}\}})$ is positive and supposed to be constant, q^{var}_{A1} and q^{var}_{B1} are larger than q^I_{A1} and q^I_{B1}. Then, we compare the varied system with (3.16) and (3.17). Due to α being positive and smaller than one, we get $q^T_{B1} > q^{var}_{B1}$ and $q^T_{A1} < q^{var}_{A1}$. That is, the value of the first-period sales q^Q_{A1} of the dominant supplier can be smaller or larger than the joint-profit maximizing q^I_{A1}. Yet, the first-period sales q^T_{B1} of the second supplier is larger than the joint-profit maximizing level. When $\beta_B q^o_{B2} < q^I_{B2}$, the considered steps yield $q^T_{B1} < q^I_{B1}$.

3.6.2 Calculations of section 3.4.2

First, suppose that learning effects do not occur. When both suppliers use simple two-part tariffs, the single-period four-stage game proceeds as follows.

Stage 4
Analogously to stage 3 in section 3.3.1, the downstream firm chooses $q^o_{At}(w^r_{At})$ if it purchases only A's good, $q^o_{Bt}(w_{Bt})$ if it purchases only B's good and $q_{At}(w^c_{At}, w_{Bt})$, $q_{Bt}(w^c_{At}, w_{Bt})$ if it purchases both goods.
Stage 3
If supplier A and downstream firm R negotiated in stage one and the negotiation of supplier B and downstream firm R failed, A and R renegotiate. Their optimization problem is

$$\max((P_A(q_{At}, 0) - w_{At})q^o_{At}(w_{At}) - F_{At})^{\beta_A} \cdot (q^o_{At}(w_{At})(w_{At} - c_{At}) + F_{At})^{1-\beta_A}.$$

Supplier A and downstream firm R choose $w^r_{At} = c_{At}$ and $F^r_{At} = (1-\beta_A)\pi^{(A)}_t$, where $\pi^{(A)}_t = \max(P_A(q_{At}, 0) - c_{At})q_{At}$. The contract maximizes the joint payoff of supplier A and downstream firm R.
Stage 2
If the negotiation between supplier A and downstream firm R in stage one fails, supplier B and downstream firm R will set $w_{Bt} = c_{Bt}$ and $F_{Bt} = (1 - \beta_B)\pi^{(B)}_t$, as in stage two of section 3.3.1.

If however negotiations between supplier A and downstream firm R succeeded, the optimization problem in stage two is

$$\begin{aligned}&\max\Big((P_A(q_{At}(w^c_{At}, w_{Bt}), q_{Bt}(w^c_{At}, w_{Bt})) - w^c_{At})q_{At}(w^c_{At}, w_{Bt})\\ &+(P_B(q_{At}(w^c_{At}, w_{Bt}), q_{Bt}(w^c_{At}, w_{Bt})) - w_{Bt})q_{Bt}(w^c_{At}, w_{Bt}) - F_{At} - F_{Bt} - \beta_A\pi^{(A)}_t\Big)^{\beta_B}\\ &\cdot\big(q_{Bt}(w^c_{At}, w_{Bt}) \cdot (w_{Bt} - c_{Bt}) + F_{Bt}\big)^{1-\beta_B}.\end{aligned}$$

The outside option of downstream firm R is set in the renegotiation stage and is given by $\beta_A\pi^{(A)}_t$. The negotiated contract is $(w_{Bt}, F_{Bt}) = (c_{Bt}, (1 - \beta_B)(\overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) - \beta_A\pi^{(A)}_t))$. The payoff of downstream firm R can be characterized by $\pi^r_{Rt}(w^c_{At}, F^c_{At}, w^o_{At}, F^o_{At}) = \beta_B\overline{\pi}_{Rt}(w^c_{At}, F^c_{At}) + (1 - \beta_B)\beta_A\pi^{(A)}_t$.
Stage 1
In stage one, the optimization problem of supplier A and downstream firm R is

$$\begin{aligned}&\max\Big(\pi^r_{Rt}(w^c_{At}, F^c_{At}, w^o_{At}, F^o_{At}) - \beta_B\pi^{(B)}_t\Big)^{\beta_A} \cdot \big(q_{At}(w^c_{At}, c_{Bt}) \cdot (w^c_{At} - c_{At}) + F^c_{At}\big)^{1-\beta_A},\\ &\text{s.t. } \pi^r_{Rt}(w^c_{At}, F^c_{At}, w^o_{At}, F^o_{At}) \geq \beta_A\pi^{(A)}_t \qquad (3.18)\end{aligned}$$

The dominant supplier and downstream firm R negotiate $w^c_{At} = c_{At}$. As condition (3.18) can be binding or non-binding the fixed fee is given by

$$F^c_{At} = \begin{cases} \pi^I_t - \beta_A \pi^{(A)}_t & \text{, if } \pi^I_t < (1 + \frac{1-\beta_A}{1-\beta_B}\beta_B)\pi^{(A)}_t - \frac{1-\beta_A}{\beta_A}\pi^{(B)}_t, \\ (1-\beta_A)(\pi^I_t - \pi^{(B)}_t + \frac{\beta_A(1-\beta_B)}{\beta_B}\pi^{(A)}_2) & \text{, else.} \end{cases}$$

In case of renegotiation, supplier A need not inevitably offer a contract menu with an exclusive and a competitive contract. A simple two-part tariff of supplier A is sufficient to achieve the industry-profit maximizing outcome. The reason is that the renegotiated contract modifies the outside option of downstream firm R in the negotiation with supplier B. Therefore, the incentive compatibility constraint of downstream firm R, respectively the participation constraint of supplier B, is altered by the renegotiation stage. An exclusive contract negotiated in stage one would have no influence on the incentive compatibility anymore.

The analysis only differs in the outside option. Thus, quantity decisions are not influenced and the final outcome is determined in the same way as noted in section 3.3.

Depending on condition (3.18), payoffs are given by

$$\pi^{*r}_{At} = \begin{cases} \pi^I_t - \beta_A \pi^{(A)}_t & \text{, if } \pi^I_t < (1 + \frac{1-\beta_A}{1-\beta_B}\beta_B)\pi^{(A)}_t - \frac{1-\beta_A}{\beta_A}\pi^{(B)}_t, \\ (1-\beta_A)(\pi^I_t - \pi^{(B)}_t + \frac{\beta_A(1-\beta_B)}{\beta_B}\pi^{(A)}_2) & \text{, else,} \end{cases}$$

$$\pi^{*r}_{Bt} = \begin{cases} 0 & \text{, if } \pi^I_t < (1 + \frac{1-\beta_A}{1-\beta_B}\beta_B)\pi^{(A)}_t - \frac{1-\beta_A}{\beta_A}\pi^{(B)}_t, \\ (1-\beta_B)\{\beta_A \pi^I_t + (1-\beta_A)\pi^{(B)}_t - \beta_A\left(1 + \frac{(1-\beta_A)(1-\beta_B)}{\beta_B}\right)\pi^{(A)}_t\} & \text{, else,} \end{cases}$$

$$\pi^{*r}_{Rt} = \begin{cases} \beta_A \pi^{(A)}_t & \text{, if } \pi^I_t < (1 + \frac{1-\beta_A}{1-\beta_B}\beta_B)\pi^{(A)}_t - \frac{1-\beta_A}{\beta_A}\pi^{(B)}_t, \\ \beta_A\beta_B\pi^I_t + (1-\beta_A)\beta_B\pi^{(B)}_t + \beta_A^2(1-\beta_B)\pi^{(A)}_t & \text{, else.} \end{cases}$$

Chapter 4

Contract Choice, Market Structure and Efficiency

4.1 Introduction

In this essay, we study the contract choice of two upstream competitors that simultaneously deal with a common buyer. Both upstream firms could use two-part tariffs or alternatively quantity-price contracts and market-share contracts. A quantity price contract fixes the quantity level besides a wholesale price and a fixed fee. A market-share contract additionally sets the share that the downstream firm has to purchase from the upstream firm. The use of the latter contract types is documented in legal cases as for example in *Brunswick* and *Intel*.[1] The main concern in these cases is that a dominant supplier could eliminate an existing competitor by offering specific contractual conditions to common customers. By accepting a predefined sales volume or relative purchase requirement, customers could be inhibited from purchasing from the competitor of the dominant supplier. In some decisions, it is shortly mentioned that competitors also used specific contract types (cf. *Brunswick* as well as *Tyco*). In others, it is questioned why the allegedly excluded competitor did not use contractual conditions to defend its market position (cf. *Intel*).

The focus of this essay lies on the contractual decision of two upstream firms in

[1] Concord Boat Corporation v. *Brunswick* Corporation 309 F:3d 494 (8th Cir. 2002); *Intel* v. Commission Decision, 2009, Case COMP/C-3/37.990. Besides these decisions, cf.: Allied Orthopedic Appliances, Inc. vs. *Tyco Health Care* Group LP, 592 F:3d 991 (9th Cir. 2010); Tomra (2010); Michelin (2003).

view of their consequences on competition, market structure and efficiency. In our model, two upstream firms simultaneously decide about their contract types and negotiate the related contractual terms with a single downstream firm. In our complete information set-up, suppliers know whether their rival and the downstream firm agreed upon a contract and, if so, they know the contract designs. This assumption seems realistic in markets with, for example, a large internet presence of final products (Iozzi & Valletti, 2014).[2]

We suppose that each supplier chooses a contract design and then bilaterally Nash bargains contractual terms with the downstream firm. The outcome is then given by the negotiated contract terms that constitute a subgame-perfect Nash equilibrium (in the Nash negotiations). This concept for simultaneous contracting games allows us to analyze contract types and their impact on competition in case of equally efficient symmetric competitors and, also, in case of a dominant supplier and its rival.

We analyze a two-period game to develop insights into contract decisions and changes in market structure in a dynamic context of inter-temporal externalities. Particularly learning effects are on the focus.

In the benchmark case without learning-by-doing, we find that all contract types lead to the same result, namely to the industry-profit maximizing outcome. That is, upstream suppliers have no incentive to choose contract specifications besides a simple two part tariff. In addition, these contracts are not used to exclude a rival supplier but to achieve the most profitable outcome for all firms (as well as for each single firm).

As a basic result, we show that in case of inter-temporal externalities, the industry-profit maximizing outcome is not achieved by any contract type used by the upstream firms. In contrast, simple two-part tariffs, quantity-price contracts and market-share contracts can lead to different outcomes and could (at least partially) exclude a rival supplier. The industry-profit maximum is desired by all firms because each firm's payoff equals a part of the joint payoffs, distributed according

[2] As an example, the number of products and product features as well as final prices are recently updated in online catalogues. Hence, upstream competitors in these markets can gain insights into the negotiations of their rivals. If, for instance, a specific computer cannot be bought with a CPU of a specific upstream firm, negotiations between this manufacturer and OEM have not taken place or failed.

to (constant) outside options and bargaining power (by the fixed fees negotiated in the contracts). That is, firms actually prefer the outcome that maximizes industry profits and do not superficially want to exclude their rivals.

We show that the specific contract choice depends on the model assumptions. When both suppliers are equally efficient and have the same contract options, quantity-price contracts are used and lead to lower sales levels than simple two-part tariffs because the contracts reduce market-based externalities in the downstream sector. Final prices are higher, efficiency gains are lower, upstream competition is dampened and social welfare is reduced by quantity-price contracts. Therefore, we find that quantity-price contracts can dampen competition even though suppliers are equally efficient.

When both suppliers are equally efficient and only one supplier can choose contractual conditions while the rival supplier can only negotiate simple two-part tariffs, the contract decision offers a dynamic advantage to the supplier with the contractual flexibility and therefore leads to Stackelberg competition. The rival supplier is at least partially excluded by the supplier's quantity-price contract or market-share contract. The reason is that the supplier and the downstream firm do not consider industry profits but only their joint payoffs. The outcome that they choose can only be bilaterally efficient. The outcome that is efficient regarding industry profits cannot be achieved. The reason is that the firms do not consider the impact of learning-by-doing on their rival supplier and therefore restrict the rival's efficiency gains.

Additionally, we show that quantity-price contracts are more profitable in situations when firms are equally efficient, and market-share contracts seem to be more profitable when the firm offering the contract is more efficient than the rival supplier. As a logical consequence, as long as rival suppliers have the same strategy options and are equally efficient, a competitor will not be excluded because it can defend its market share by offering quantity-price contracts. If however, production efficiency varies considerably across upstream suppliers, it can be more profitable for all firms when only the more efficient firm offers a market-share contract. When demand is linear, market-share contracts always decrease consumer surplus and social welfare.

With regard to the latter results, we develop new insights about the contractual decisions of upstream competitors and their consequences. The contract choice of upstream suppliers depends on specific market parameters, in particular on the consideration of inter-temporal externalities. These, in turn, influence the market structure and welfare.

Related literature

Different modeling approaches have been developed to investigate bilateral contracts in buyer-seller networks. A standard concept that is applied in the literature is the Nash-in-Nash concept, see for example Horn and Wolinsky (1988). The approach combines a cooperative game theory concept (Nash bargaining) with a non-cooperative one (Nash equilibrium). In case of a single bilateral negotiation, Binmore, Rubinstein, and Wolinsky (1986) show that the solution of cooperative Nash bargaining can be determined by the non-cooperative alternating offer game of Rubinstein. For the case of multiple bilateral negotiations between upstream and downstream firms, it can also be shown that the outcome of the Nash-in-Nash concept is similar to the one when upstream and downstream firms make alternating offers, see Collard-Wexler, Gowrisankaran, and Lee (2014) as well as Björnerstedt and Stennek (2007). Hence, the Nash-in-Nash concept can be interpreted as a purely non-cooperative concept.

Recent articles, as for example Guo and Iyer (2013) and Wilson (2014) use the Nash-in-Nash concept to analyze simultaneous bargaining and compare the outcome with the one in case of sequential negotiations.

In these articles, it is assumed that the contracts of buyer-seller pairs are only observable for the negotiating partners. Further agents in the network do not know whether the bilateral negotiations of their competitors succeeded or failed.

Iozzi and Valletti (2014) investigate a model with a monopolistic upstream firm negotiating with two competing downstream firms. Iozzi and Valletti emphasize that the assumption on the observability of contracts is essential. They call the agreements of Horn and Wolinsky (1988) unobservable contracts. In comparison, they study the situation where downstream firms know whether negotiations between the downstream rival and the upstream firm failed or succeeded, and they know the negotiated contract terms (observable contracts). The observability leads to a change in outside options and therefore to a different outcome. They illustrate that both scenarios, with observable and unobservable contracts, occur in reality, depending on specific circumstances.[3]

Our model is related to Iozzi and Valletti (2014) as we analyze a framework with complete information in which all firms know whether further negotiations take place and which kind of contract terms are negotiated. Though, the influence of observability on outside options and therefore on the final outcome differs in our set-up, because of the varied market structure (two upstream firms, a single downstream firm).

A second axiomatic approach shows that the Shapley value is generated by bilateral negotiations of upstream and downstream firms (de Fontenay & Gans, 2014; Inderst & Wey, 2003). In a similar way to Nocke and Rey (2014), de Fontenay and Gans (2014) assume that firms have passive beliefs about the negotiations of their rivals. Therefore, a unique equilibrium exists, unlike in the results of many set-ups with incomplete information and multiple simultaneous negotiations. Considering that firms can renegotiate their contracts, the outcome is shown to be bilaterally efficient. Montez (2014) also notes that results depend on the fact whether contract terms can be renegotiated.

A third recent approach is presented by Inderst and Montez (2014). They introduce bilateral negotiations determined by auctions. Depending on the bargaining power, the negotiated terms are either more similar to the bid that the upstream firm chooses or more similar to the bid of the downstream firm.

Our model builds on the Nash-in-Nash concept as it fits best to analyze and compare different contract types. Comparing different contract scenarios and the impact on competition, our model is related to Milliou and Petrakis (2007), Milliou, Petrakis, Sachtachtinskagia, and Vettas (2008), and Ramezzana (2014). Milliou and Petrakis (2007) compare the use of two-part tariffs and linear contracts. They show in a framework with two supply chains that an upstream merger can lead to a change regarding the profitably used contract types. Milliou et al. (2008) investigate price-quantity bundle contracts in a setting with two vertical chains. They show that the mode of competition may be influenced by the contract choice. Calzolari and Denicolò (2013) compare contract menus with exclusive dealing contracts and market-share discounts. Considering only symmetric equilibria in which two firms use the same contractual terms, they show that exclusive contracts may increase

[3] In addition, Inderst (2010) emphasizes that model assumptions/negotiation design depends on the circumstances of the specific market.

competition while market-share conditions dampen competition.

Our model contributes to this literature as we compare simple two-part tariffs, own-quantity contracts as well as market-share contracts. To the best of our knowledge, these contract types have not been investigated in a vertical structure with learning-by-doing and simultaneous negotiations. Moreover, our model allows us to analyze three scenarios. First, we develop symmetric contractual decisions. Second, we investigate the case where only one supplier is flexible in its contract choice and is therefore dominant toward the rival supplier. Third, we allow for the asymmetric case where both suppliers can simultaneously decide about different contract types.

4.2 Framework

Two upstream firms, A and B, supply differentiated products to downstream firm R. As the single firm in the downstream market, R sells the goods to final consumers. The inverse demand system $P_A(q_A, q_B), P_B(q_A, q_B)$ depends on the consumption of the two goods. As the goods are imperfect substitutes, the inverse demand fulfills $\frac{\partial P_J}{\partial q_J} < \frac{\partial P_J}{\partial q_K} < 0$ whenever $P_J(q_A, q_B) > 0$ for $J, K \in \{A, B\}$. For some cases, a specification of the demand system is necessary to obtain explicit solutions. In these cases, we assume the linear system

$$P_A(q_A, q_B) = 1 - q_A - \gamma q_B,$$
$$P_B(q_A, q_B) = 1 - q_B - \gamma q_A,$$

where the degree of substitutability is denoted by $\gamma \in (0, 1)$.

To investigate inter-temporal externalities, we analyze a two-period model, where the demand is time-invariant. In the first period, the suppliers A and B face marginal costs of production given by c_A and c_B. For simplicity, the downstream firm has no additional costs but the contractual agreements with the suppliers. In the second period learning effects occur and therefore marginal costs c_{A2}, c_{B2} decrease with respect to first-period sales

$$c_{J2} = \max\{c_J - \lambda q_{J2}, 0\},$$

with the learning parameter $\lambda > 0$. Note that in case of a linear demand system, the expression leads to the same impact as consumption externalities, presuming that these effects increase demand with respect to first-period sales.

We assume that the suppliers simultaneously negotiate with the downstream firm. The bargaining power of downstream firm R vis-à-vis supplier J is $\beta_J \in [0,1]$. Regarding the negotiating process we consider Nash bargaining. Solving the Nash product of supplier J and downstream firm R yields the contractual terms of this bilateral bargain depending on the contractual terms between $K(\neq J)$ and R. Hence, the contractual terms represent the response function of supplier J and R. We then solve for the Nash equilibrium of this simultaneous move game by solving the response functions. With this 'Nash-in-Nash' concept, we follow the bilateral bargaining procedure of multiple agents introduced by Horn and Wolinsky (1988). An interpretation of the concept is that the downstream firm sends an agent to each supplier to negotiate contractual terms. Therefore, both agents represent the downstream firm, but they do not know the exact state of the other bilateral negotiation.

We assume a model with complete information in which the suppliers know whether their rival and the downstream firm agreed upon a contract and, if so, they know the contract designs. On the one hand, this assumption seems realistic in markets with, for example, a large internet presence of final products (Iozzi & Valletti, 2014). On the other hand, this assumption represents the situation where firms can renegotiate from scratch. That is, after the suppliers and the downstream firm bilaterally negotiated, the suppliers get to know whether the negotiation of their rival succeeded or failed. If it failed, they can renegotiate contract terms. This assumption leads to the same outside options and outcomes as in the case of complete information introduced above.

We allow for several contract types to be negotiated in the Nash bargaining processes. First, the suppliers could choose a simple two-part tariff (T) that determines a wholesale price w and a fixed fee F. Second, they could choose a quantity-price contract (Q) where a quantity level q_J is negotiated upon, depending on the wholesale price and optionally a fixed fee. Third, (one of the) suppliers can use market-share contracts (M).[4] In the following, market-share contracts additionally fix a specific share requirement. That is, market-share contracts offer the highest number of contractual terms. Due to the market-share term in combination with

[4]In our setting with only two upstream firms, it does not make sense to assume that both suppliers choose market-share contracts. This could be an interesting extension of the model in a context with more than two suppliers.

the quantity term, all quantity levels are negotiated upon, by the defined type of market-share contracts.[5]

The timing of the game is as follows:

First, in stage 0, the suppliers choose the contract types that will be negotiated with the downstream firm. A and B inform the downstream firm about their decisions. In stage 1, the agents of the downstream firm simultaneously negotiate contractual terms with the suppliers. Both agent and supplier pairs know whether the other negotiation breaks down. In addition, they know about both contract types. That is, we assume that the agents will disclose information to the suppliers. In stage 2 of each single period, the downstream firm chooses final prices, respectively quantities according to the negotiated contractual conditions. Figure 4.1 illustrates the timing of the two-period model.

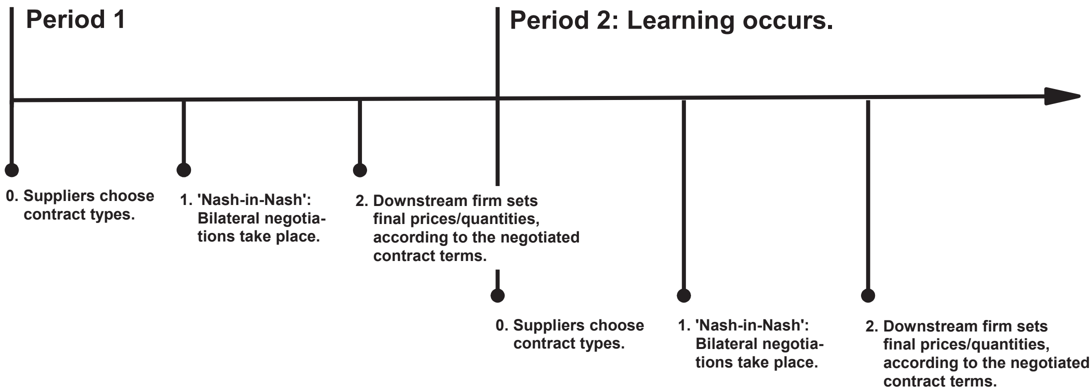


Figure 4.1: Timing of the two-period model.

In the following, we assume that contracts are arranged only for a single period. That is, after period one ends, learning effects occur and a second period starts in which new single-period contracts are negotiated upon.

To solve the model, we determine the outcomes of the possible contract combinations. The comparison of related profits reveals the strategy choice in stage 0. For this strategy stage, we assume different scenarios. First, we develop the symmetric equilibria in which both suppliers use the same contract types. Second, only

[5]Note that this specification represents the case of a market-share contract combined with a quantity-forcing contract or respectively a (binding) volume discount. The application of this combination of contract specifications is, for example, noted in Brunswick (2002).

one supplier could be strategic in stage 0 and the second supplier is restricted to negotiate simple two-part tariffs. This scenario represents dominance. Third, both suppliers could choose different contract types.

4.3 Model

4.3.1 The benchmark case (no learning-by-doing)

Without inter-temporal externalities, a single-period model is sufficient to analyze the final outcome and strategy choice of the firms. We start by analyzing the situation where both suppliers are restricted to use simple two-part tariffs, and solve the multi-stage game by backwards induction.

If the negotiation between supplier A and downstream firm R fails, only supplier B and downstream firm R will negotiate. Simple two-part tariffs lead to maximum joint payoffs, divided by the bargaining power β_B. That is, downstream firm R earns $\pi_{Rt}^{(B)} = \beta_B \pi_t^{(B)}$ and supplier B earns $\pi_{Bt}^{(B)} = (1-\beta_B)\pi_t^{(B)}$ where maximum joint payoffs are $\pi_t^{(B)} = \max(P_B(q_{Bt}, 0) - c_{Bt})q_{Bt}$.

Analogously, if the negotiation between supplier B and downstream firm R fails, the downstream firm will earn $\pi_{Rt}^{(A)} = \beta_A \pi_t^{(A)}$, and supplier A earns $\pi_{At}^{(A)} = (1-\beta_A)\pi_t^{(A)}$ where $\pi_t^{(A)} = \max(P_A(q_{At}, 0) - c_{At})q_{At}$.

If, however, both suppliers successfully negotiate simple two-part tariffs, the quantities chosen by the downstream firm in the last stage are determined by maximizing payoffs $\pi_{Rt}(q_{At}, q_{Bt}) = (P_A(q_{At}, q_{Bt}) - w_{At})q_{At} + (P_B(q_{At}, q_{Bt}) - w_{Bt})q_{Bt} - F_{At} - F_{Bt}$. That is, quantities $q_{At}(w_{At}, w_{Bt})$, $q_{Bt}(w_{At}, w_{Bt})$ are characterized by

$$\frac{\partial P_A}{\partial q_{At}} q_{At} + \frac{\partial P_B}{\partial q_{At}} q_{Bt} + P_A(q_{At}, q_{Bt}) - w_{At} = 0,$$
$$\frac{\partial P_A}{\partial q_{Bt}} q_{At} + \frac{\partial P_B}{\partial q_{Bt}} q_{Bt} + P_B(q_{At}, q_{Bt}) - w_{Bt} = 0.$$

Solving by backwards induction, the suppliers consider the quantity choice of downstream firm R in the negotiations of their two-part tariffs with R. The optimization problem of supplier A and downstream firm R depends on the two-part tariff of supplier B and downstream firm R. It is given by

$$\max \left(\pi_{At}(w_{At}, F_{At}, w_{Bt}, F_{Bt}) - 0\right)^{1-\beta_A} \cdot \left(\pi_{Rt}(w_{At}, F_{At}, w_{Bt}, F_{Bt}) - \pi_{Rt}^{(B)}\right)^{\beta_A}$$

where payoffs of supplier A are $\pi_{At}(w_{At}, F_{At}, w_{Bt}, F_{Bt}) = q_{At}(w_{At}, w_{Bt})(w_{At} - c_{At}) + F_{At}$
and payoffs of downstream firm R are given by $\pi_{Rt}(w_{At}, F_{At}, w_{Bt}, F_{Bt}) = \pi_{Rt,var}(w_{At}, w_{Bt}) - F_{At} - F_{Bt}$ whereby variable profits are denoted by

$$\begin{aligned}\pi_{Rt}^{var}(w_{At}, w_{Bt}) =&(P_A(q_{At}(w_{At}, w_{Bt}), q_{Bt}(w_{At}, w_{Bt})) - w_{At})q_{At}(w_{At}, w_{Bt})\\ &+ (P_B(q_{At}(w_{At}, w_{Bt}), q_{Bt}(w_{At}, w_{Bt})) - w_{Bt})q_{Bt}(w_{At}, w_{Bt}).\end{aligned}$$

$\pi_{Rt}^{(B)}$ is the outside option in the bilateral negotiation with supplier A.[6]

When all suppliers negotiate simple two-part tariffs, the best reaction of supplier A and downstream firm R on the contract of supplier B and R is the two-part tariff

$$\begin{aligned}w_{At} &= c_{At},\\ F_{At} &= (1-\beta_A)(\pi_{Rt}^{var}(c_{At}, w_{Bt}) - F_{Bt} - \pi_{Rt}^{(B)})\end{aligned}$$

Analogously, the reaction of supplier B and downstream firm R is

$$\begin{aligned}w_{Bt} &= c_{Bt},\\ F_{Bt} &= (1-\beta_B)(\pi_{Rt}^{var}(w_{At}, c_{Bt}) - F_{At} - \pi_{Rt}^{(A)})\end{aligned}$$

In equilibrium, the contracts are given by

$$\begin{aligned}w_{At}^T &= c_{At}, \quad F_{At}^T = \frac{1-\beta_A}{1-(1-\beta_A)(1-\beta_B)}(\beta_B\pi_t^I + (1-\beta_B)\pi_{Rt}^{(A)} - \pi_{Rt}^{(B)}),\\ w_{Bt}^T &= c_{Bt}, \quad F_{Bt}^T = \frac{1-\beta_B}{1-(1-\beta_A)(1-\beta_B)}(\beta_A\pi_t^I + (1-\beta_A)\pi_{Rt}^{(B)} - \pi_{Rt}^{(A)}).\end{aligned}$$

Here, the final outcome equals the industry profit maximizing one (q_{At}^I, q_{Bt}^I) because wholesale prices equal marginal costs, and the downstream firm maximizes payoffs similarly to an integrated firm. Maximum industry profits are denoted by π_t^I. Payoffs are given by

$$\pi_{Rt}^* = \frac{1}{1-(1-\beta_A)(1-\beta_B)}(\beta_A\beta_B\pi_t^I + \beta_A(1-\beta_B)\pi_{Rt}^{(A)} + \beta_B(1-\beta_A)\pi_{Rt}^{(B)}), \quad (4.1)$$

$$\pi_{At}^* = \frac{1-\beta_A}{1-(1-\beta_A)(1-\beta_B)}(\beta_B\pi_t^I + (1-\beta_B)\pi_{Rt}^{(A)} - \pi_{Rt}^{(B)}), \quad (4.2)$$

$$\pi_{Bt}^* = \frac{1-\beta_B}{1-(1-\beta_A)(1-\beta_B)}(\beta_B\pi_t^I + (1-\beta_A)\pi_{Rt}^{(B)} - \pi_{Rt}^{(A)}). \quad (4.3)$$

[6]The outside option depends on the observability of contracts. If contracts are not observable, the outside option would depend on the contractual terms of supplier B.

Note that due to our assumption on imperfect substitutes, both products are sold in equilibrium if the difference in marginal costs is not extremely large. Payoffs are non-negative and an exclusion of a supplier does not occur.

Note however that if marginal costs strongly differ, the downstream firm purchases and resells only the good of the more efficient supplier (in this case $\pi_t^I = \pi_t^{(J)}$). Then, it is not profitable to offer both goods. It can be more profitable for the downstream firm to negotiate only with the more efficient supplier ($\pi_{Rt}^*|_{\{q_{Kt}^I=0\}} < \pi_{Rt}^{(J)}$). In this specific case, payoffs are

$$\begin{aligned}
\pi_{Rt}^{**} &= \pi_{Rt}^{(J)}, \\
\pi_{Kt}^{**} &= 0, \\
\pi_{Jt}^{**} &= \pi_{Jt}^{(J)},
\end{aligned}$$

where supplier J is the more efficient firm.

In sum, simple two-part tariffs already lead to the industry-profit maximizing outcome. Hence, joint payoffs of the firms are maximal and divided according to the bargaining power as well as outside options. None of the suppliers is better off by offering further contract types. That is, in a single period setting without learning-by-doing, there is no need for specifying further contractual conditions.

The single-period result implies that the outcome of the Nash-in-Nash concept equals the outcome of multi-person Nash bargaining (Harsanyi, 1977). The reason is that contracts are observable, therefore outside options are constant and given by $\pi_{Rt}^{(A)}$, $\pi_{Rt}^{(B)}$, and contracts have at least two instruments - one to influence the quantity choice and one to shift rents. That is, the contracts have enough instruments to influence the strategy choice of the downstream firm and therefore, the first-order conditions that solve for the Nash equilibrium outcome (in the Nash-in-Nash concept) are similar to the conditions that solve the multi-person Nash bargaining game.[7]

[7]For the determination of the outcome in case of quantity-price contracts, see for example O'Brien and Shaffer (2005).

4.3.2 Inter-temporal externalities

In this section, we consider brand-specific inter-temporal externalities. In particular, we concentrate on learning effects. That is, marginal costs of supplier $J = A, B$ decrease with respect to its first-period sales.[8] We assume that the suppliers are symmetric concerning (initial) marginal costs and bargaining power, that is $c_A = c_B > 0$ and $\beta_A = \beta_B$.We concentrate on the case of positive second-period marginal costs, $c_{A2}, c_{B2} \gneq 0$. Moreover, we assume that the quantities q^I_{A1}, q^I_{B1} that maximize long-run industry profits are both positive.

The two-period model is solved by backwards induction. Starting in the second period, the outcome q_{A2}, q_{B2} is similar to the one determined in section 4.3.1. Second-period payoffs are given by π^*_{R2}, π^*_{A2}, π^*_{B2} and depend on second-period marginal costs c_{A2}, c_{B2}, thus on first-period sales.

In period one, firms consider long-run payoffs $\Pi_J = \pi_{J1}(q_{A1}, q_{B1}) + \pi^*_{J2}(c_{A2}, c_{B2})$.[9] To analyze first-period decisions, it is necessary to restrict ourselves to concave long-run profit functions.

Assumption 4.1 (Uniqueness)**.**
For the long-run industry profit function

$$\Pi_I = (P_A(q_{A1}, q_{B1}) - c_A)q_{A1} + (P_B(q_{A1}, q_{B1}) - c_B)q_{B1} + \pi^I_2(c_{A2}, c_{B2}),$$

the long-run payoff function of downstream firm R

$$\Pi_R = (P_A(q_{A1}, q_{B1}) - w_{A1})q_{A1} + (P_B(q_{A1}, q_{B1}) - w_{B1})q_{B1} + \pi^*_{R2}(c_{A2}, c_{B2}),$$

as well as the combined long-run profit functions of supplier $J = A, B$ and downstream firm R

$$(P_A(q_{A1}, q_{B1}) - c_A)q_{A1} + (P_B(q_{A1}, q_{B1}) - w_{B1})q_{B1} + \pi^*_{R2}(c_{A2}, c_{B2}) + \pi^*_{A2}(c_{A2}, c_{B2}), \text{ and}$$
$$(P_A(q_{A1}, q_{B1}) - w_{A1})q_{A1} + (P_B(q_{A1}, q_{B1}) - c_B)q_{B1} + \pi^*_{R2}(c_{A2}, c_{B2}) + \pi^*_{B2}(c_{A2}, c_{B2}),$$

the Hessian matrices are negative definite.

[8]Introducing consumption externalities in case of a linear demand system leads to the same qualitative results as learning-by-doing.

[9]For simplicity, we assume that the time discount factor δ is one.

Considering the first part of assumption 4.1, the long-run industry-profit maximizing quantities will be positive and equal because marginal costs and bargaining power are assumed to be even.

The last part of assumption 4.1 ensures that the Nash bargaining of supplier J and downstream firm R can be solved. The negotiated contractual terms maximize the cumulated long-run payoffs of both firms, depending on the quantity choice of the downstream firm in stage 2.

Note, however, that the supplier and downstream firm R will not consider second-period payoffs of the second supplier in their bilateral negotiation. Therefore, the first-period response functions cannot solve for the industry profit maximizing outcome.[10] The best response of supplier A and downstream firm R does not consider the impact of π^*_{B2}. Analogously, supplier B and downstream firm R do not take into account the impact of π^*_{A2} on long-run payoffs. In particular, second-period payoffs depend on second-period marginal costs and therefore on first-period sales. The quantity decision in a bilateral negotiation only includes the second-period payoffs of the negotiating parties and cannot take into account second-period payoffs of the rival supplier.

This result is independent of the contract types chosen by the suppliers. The reason is that, even with a maximum number of instruments in a contract, only the cumulated payoffs of the downstream firm and one supplier are taken into account. Yet, it is possible that specific contract types chosen by the suppliers solve for an outcome that is closer to the industry profit maximizing one than another combination of contracts.

By analogy to the benchmark case, long-run profits of firms A, B, R are equal to a share of long-run industry profits, depending on bargaining power and the outside options. We assume here, that the first-period outside option of the downstream firm $\Pi_R^{(K)}$ while negotiating with supplier J is to purchase only from supplier K in

[10]The only exception in case of single period contracts is the situation where bargaining power equals one, $\beta_A = \beta_B = 1$. In this case, the downstream firm has all the bargaining power and will maximize industry profits. In addition, note that the industry-profit maximizing outcome is achieved when both suppliers negotiate long-run contracts. In particular, if both suppliers negotiate first-period and second-period wholesale prices and fixed fees in the first period, the downstream firm would not consider the impact of learning on its own outcome. Due to this reason, the externality that occurs in case of single-period contracts (see below) is eliminated and the industry profit maximizing outcome can be achieved.

period one and, as long as it is profitable to do so, purchasing from both suppliers in period two. The outside option of supplier J is consequently its second-period payoff $\pi^*_{J2}(c_J, c^{(K)}_{K2})$ given that R purchases its good in period two (if the difference between A's and B's costs are not too large). Therefore, first-period outside options are constant. Combined with the exogenously given constant bargaining powers β_A and β_B, the bargaining positions of the suppliers and the downstream firm are fixed.

Hence, a change in final quantities has the same proportional effect on long-run profits for all firms. If a supplier changes its first-period contract choice to maximize its own profits, the second supplier and the downstream firm will also benefit from the new contract specifications, proportionally to their bargaining powers.

The question that arises is whether the suppliers can achieve a better result (meaning one that is closer to the industry profit maximum) by choosing a contract type different from simple two-part tariffs. In the following, we subdivide the analysis into two parts. First, we suppose that the contract decision is symmetric (first scenario). That is, both suppliers choose similar contract types. Then, we analyze asymmetric combinations. In this case, suppliers can choose a contract type different from the one of its rival. On the one hand, the asymmetric combinations allow us to analyze the case where only one supplier can set further contract specifications besides simple two-part tariffs (dominant supplier). On the other hand, we are able to determine the sub-game perfect Nash equilibrium for the case that both suppliers can choose different contract types.

4.3.2.1 Symmetric contract choice

There are two potential candidates for the symmetric contract combinations. First, both suppliers could choose to negotiate simple two-part tariffs. Second, the alternative combination is to choose quantity-price contracts. Note that a symmetric case with market-share contracts does not exist in our setting with only two suppliers. The downstream firm cannot commit itself to stick to two market-share levels.[11]

[11] The only possibility for a symmetric case with market-share contract is to prescribe the market share to be 50%. See, for example, Calzolari and Denicolò (2013) for an investigation of market-share contracts. We are interested in the negotiation of contract terms and their consequences. Therefore, we exclude the possibility of symmetric market-share contracts.

Two-part tariffs

Solving by backwards induction, we proceed in a similar way to section 4.3.1.

If R purchases only the good of supplier A in period one, the negotiated two-part tariff leads to maximum cumulated long-run payoffs of A and R. The equilibrium quantity is denoted by $q_{A1}^{(A)}$. Payoffs are divided according to the bargaining power β_A and given by $\Pi_A^{(A)}$ and $\Pi_R^{(A)}$. By analogy, supplier B and downstream firm R achieve $\Pi_B^{(B)}$ and $\Pi_R^{(B)}$, if R purchases only the good of supplier B.[12] As long as the suppliers are symmetric ($\beta_A = \beta_B$ and $c_A = c_B$), these outside options are equal.

If R purchases both goods, the quantity choice $q_{A1}(w_{A1}, w_{B1})$, $q_{B1}(w_{A1}, w_{B1})$ is characterized by

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - w_{A1} - \lambda \frac{\partial \pi_{R2}^*}{\partial c_{A2}} = 0, \tag{4.4}$$
$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - w_{B1} - \lambda \frac{\partial \pi_{R2}^*}{\partial c_{B2}} = 0. \tag{4.5}$$

Note that the downstream firm only considers the impact of learning-by-doing on its own payoffs, differing from long-run industry payoffs.

In stage one, downstream firm R and supplier A negotiate a simple two-part tariff. Their optimization problem is

$$\max_{w_{A1}, F_{A1}} \left(\Pi_R(w_{A1}, F_{A1}, w_{B1}, F_{B1}) - \Pi_R^{(B)}\right)^{\beta_A} \cdot \left(\Pi_A(w_{A1}, F_{A1}, w_{B1}) - \pi_{A2}^*(c_A, c_{B2}^{(B)})\right)^{1-\beta_A}$$
$$\text{s.t.} \quad \Pi_R(w_{A1}, F_{A1}, w_{B1}, F_{B1}) \geq \Pi_R^{(B)}, \text{ and } \Pi_A(w_{A1}, F_{A1}, w_{B1}) \geq \pi_{A2}^*(c_A, c_{B2}^{(B)}).$$

Here, long-run profits depending on the negotiated contractual terms are given by

$$\begin{aligned} \Pi_R(w_{A1}, F_{A1}, w_{B1}, F_{B1}) =& (P_A(q_{A1}(w_{A1}, w_{B1}), q_{B1}(w_{A1}, w_{B1})) - w_{A1}) q_{A1}(w_{A1}, w_{B1}) \\ &+ (P_B(q_{A1}(w_{A1}, w_{B1}), q_{B1}(w_{A1}, w_{B1})) - w_{B1}) q_{B1}(w_{A1}, w_{B1}) \\ &- F_{A1} - F_{B1} + \pi_{R2}^*(c_{A2}, c_{B2}), \\ \Pi_A(w_{A1}, F_{A1}, w_{B1}) =& q_{A1}(w_{A1}, w_{B1})(w_{A1} - c_A) + F_{A1} + \pi_{A2}^*(c_{A2}, c_{B2}). \end{aligned}$$

[12] This outcome as well as the following ones depend on the assumption of complete information. In particular, the suppliers know whether R purchases both goods or only one due to the agents' information. Additionally, it is not profitable for the downstream firm to negotiate a contract with at least a wholesale price and a positive fixed fee, and then to skip buying the product.

The two-part tariff between A and R is characterized by the conditions[13]

$$w_{A1} = c_A + \lambda \frac{\partial \pi^*_{A2}}{\partial c_{A2}} + \lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(w_{A1}, w_{B1})/\partial w_{A1}}{\partial q_{A1}(w_{A1}, w_{B1})/\partial w_{A1}}, \tag{4.6}$$

$$\beta_A(\Pi_A(w_{A1}, F_{A1}, w_{B1}) - \pi^*_{A2}(c_A, c^{(B)}_{B2})) = (1-\beta_A)(\Pi_R(w_{A1}, F_{A1}, w_{B1}, F_{B1}) - \Pi^{(B)}_R) \tag{4.7}$$

Note that the partial derivatives of π^*_{A2} (and π^*_{B2}) generally depend on second-period marginal costs. That is, the partial derivatives depend on first-period sales $q_{A1}(w_{A1}, w_{B1})$, $q_{B1}(w_{A1}, w_{B1})$ and thus on both wholesale prices w_{A1}, w_{B1}. As such, equation (4.6) has to be solved with respect to w_{A1} and will generally depend on w_{B1}.

Analogously, the negotiated two-part tariff of B and R is characterized by

$$w_{B1} = c_B + \lambda \frac{\partial \pi^*_{B2}}{\partial c_{B2}} + \lambda \frac{\partial \pi^*_{B2}}{\partial c_{A2}} \frac{\partial q_{A1}(w_{A1}, w_{B1})/\partial w_{B1}}{\partial q_{B1}(w_{A1}, w_{B1})/\partial w_{B1}}, \tag{4.8}$$

$$\beta_B(\Pi_A(w_{A1}, w_{B1}, F_{B1}) - \pi^*_{B2}(c^{(A)}_{A2}, c_B)) = (1-\beta_B)(\Pi_R(w_{A1}, F_{A1}, w_{B1}, F_{B1}) - \Pi^{(A)}_R) \tag{4.9}$$

Equations (4.6) and (4.8) solve for the optimal wholesale prices in case of simple two-part tariffs. Inserting the wholesale prices into (4.4), (4.5) yields the outcome $q^{T,T}_{A1}$, $q^{T,T}_{B1}$.

The fact that R considers only its own impact of learning effects in stage 2, and not the impact on (second-period) payoffs of supplier A and B, leads to an externality that supplier A and supplier B try to balance with their wholesale prices. If both goods are purchased in the second period, wholesale prices in the first period are below cost.[14] The reason for below-cost pricing is the externality caused by learning-by-doing in the downstream sector and the fact that suppliers want to increase their own efficiency gains, at the expense of the rival supplier. The suppliers will benefit from larger sales levels of their own good more than the downstream firm does. A decrease of wholesale prices increases the quantity levels in equilibrium. Comparing the first-order conditions that solve for the industry-profit

[13]The outside options of the downstream firm, $\Pi^{(A)}_R$ and $\Pi^{(B)}_R$, are equal. Due to this and the fact that goods are imperfect substitutes, both suppliers will successfully negotiate contractual terms with downstream firm R.

[14]See the representation of partial derivatives of the second-period payoffs in the appendix, section 4.6.

maximum and (4.4), (4.5) (with (4.6), (4.8)), the outcome in case of two-part tariffs $q_{A1}^{T,T} = q_{B1}^{T,T}$ is larger than the industry-profit maximizing one q_{A1}^{I}, q_{B1}^{I}.

Quantity-price contracts negotiated by both suppliers

When both suppliers offer a quantity-price contract, the downstream firm has no quantity decision in stage 2 as the quantity levels are set in stage 1.

The negotiation of supplier A and downstream firm R yields $q_{A1}^{Q,Q}$, $w_{A1}^{Q,Q}$ and $F_{A1}^{Q,Q}$, given by

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \lambda \frac{\partial \pi_{R2}^*}{\partial c_{A2}} - \lambda \frac{\partial \pi_{A2}^*}{\partial c_{A2}} = 0, \tag{4.10}$$

$$\begin{aligned} &\beta_A(\Pi_A(q_{A1}, w_{A1}, F_{A1}, q_{B1}) - \pi_{A2}^*(c_A, c_{B2}^{(B)})) \\ &\quad = (1-\beta_A)(\Pi_R(q_{A1}, w_{A1}, F_{A1}, q_{B1}, w_{B1}, F_{B1}) - \Pi_R^{(B)}). \end{aligned} \tag{4.11}$$

Analogously, the negotiation of supplier B and downstream firm R yields $q_{B1}^{Q,Q}$, $w_{B1}^{Q,Q}$, and $F_{B1}^{Q,Q}$ according to

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \lambda \frac{\partial \pi_{R2}^*}{\partial c_{B2}} - \lambda \frac{\partial \pi_{B2}^*}{\partial c_{B2}} = 0, \tag{4.12}$$

$$\begin{aligned} &\beta_B(\Pi_B(q_{A1}, q_{B1}, w_{B1}, F_{B1}) - \pi_{B2}^*(c_{A2}^{(A)}, c_B)) \\ &\quad = (1-\beta_B)(\Pi_R(q_{A1}, w_{A1}, F_{A1}, q_{B1}, w_{B1}, F_{B1}) - \Pi_R^{(A)}). \end{aligned} \tag{4.13}$$

Equations (4.10) and (4.12) determine the equilibrium outcome $q_{A1}^{Q,Q}$, $q_{B1}^{Q,Q}$.

Proposition 4.1 (Quantity-price contracts).
In comparison to simple-two-part tariffs, the quantity levels $q_{A1}^{Q,Q}$, $q_{B1}^{Q,Q}$ are lower when both suppliers choose quantity-price contracts in stage 0, that is $q_{A1}^{Q,Q} = q_{B1}^{Q,Q} < q_{A1}^{T,T} = q_{B1}^{T,T}$.

The proof is delegated to the appendix, section 4.6.
The quantity decision of the downstream firm is omitted when both suppliers choose quantity-price contracts. Thus, the externality which appears because R sets quantities that maximize only its own long-run profits, does not appear. The quantity decision in case of quantity-price contracts is closer to the industry-profit maximizing outcome. In particular, quantities are larger than the industry-profit maximizing ones, but smaller than the ones in case of simple two-part tariffs. First, proposition 4.1 implicates that final prices are larger in case of quantity-price contracts

than in case of simple two-part tariffs. Second, it implicates that learning effects of both suppliers, respectively their efficiency gains, are smaller than in case of simple two-part tariffs. In sum, (long-run) competition between A and B is dampened.

Corollary 4.1 (Symmetric strategies, contract choice and implications). *Consider only the cases where both suppliers act strategically and use the same contract types. In this scenario, suppliers strictly prefer quantity-price contracts to simple-two-part tariffs. Both firms are active, and increase long-run profits by negotiating quantity-price contracts. However, social welfare is smaller than in case of simple two-part tariffs.*

Corollary 4.1 summarizes the consequences of proposition 4.1. If both upstream firms are symmetric and strategic, they will profitably negotiate quantity-price contracts with the downstream firm. These contracts used by both suppliers reduce the externalities that are caused by learning effects.

From a social welfare point of view, it can be assumed that the case of simple two-part tariffs is more desirable than the case with quantity-price contracts. It is rather the case that a ban on quantity-price contracts could increase consumer surplus and social welfare because quantities are larger in case of simple two-part tariffs.[15]

4.3.2.2 Asymmetric contract choice

In this section, we allow for contract combinations that are achievable with simple two-part tariffs, quantity-price contracts and market-share contracts.

We suppose that only one supplier can offer specified contract terms. Without loss of generality, suppose that supplier A can choose between simple two-part tariffs, quantity-price contracts and market-share contracts. In this case, supplier B is restricted to negotiate a simple two-part tariff with downstream firm R.

[15] Note, however, that this consideration is not generally determined because below-cost pricing occurs in the first period, and therefore the quantity levels that maximize welfare could also be lower than q^T_{A1}, q^T_{B1}. In case of a linear demand system, it can be shown that social welfare is harmed by quantity-price contracts.

Quantity-price contract of supplier A

Suppose that supplier A changes its decision in stage 0, and chooses a quantity-price contract.

In this case, the quantity decision of downstream firm R in stage 2 of the first period only refers to the quantity q_{B1}, as q_{A1} is fixed by the contract with supplier A. The quantity of good B $q_{B1}(q_{A1}, w_{B1})$ depends on the wholesale price of B and the quantity level of A. The profit-maximizing choice of q_{B1} of R is given by

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - w_{B1} - \lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} = 0. \tag{4.14}$$

As the quantity of supplier A is not chosen by R, downstream firm R does not consider the impact of learning-by-doing (regarding A's good) on its own payoffs in stage 2. In contrast to the case with simple two-part tariffs, this decision is jointly made by downstream firm R and supplier A in stage 1. In the dynamic game, q_{A1} is set before q_{B1}. In this way, supplier A prevents that the downstream firm only considers its own impact of learning-by-doing on its payoffs with regard to good A. The second supplier has to deal with the stage 2 externality. Therefore, a quantity-price contract presents a competitive advantage to supplier A over supplier B. In this case, the market structure changes. Suppliers become Stackelberg competitors where the firm using the quantity-price contract represents the leader.

The optimization problems of supplier A and R as well as supplier B and R are quite similar to the ones noted above. The quantity level q_{A1}, negotiated by A and R, and the wholesale price w_{B1}, negotiated by B and R represent the equilibrium outcome. They are characterized by the conditions

$$\begin{aligned} &\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1}(q_{A1}, w_{B1}) + P_A(q_{A1}, q_{B1}(q_{A1}, w_{B1})) - c_A \\ &\qquad - \lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{A2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(q_{A1}, w_{B1})}{\partial q_{A1}} = 0, \end{aligned} \tag{4.15}$$

$$w_{B1} = c_B + \lambda \frac{\partial \pi^*_{B2}}{\partial c_{B2}}. \tag{4.16}$$

Equations (4.15) and (4.16) solve for the optimal levels $q^{Q,T}_{A1}$, $w^{Q,T}_{B1}$. Then, $q^{Q,T}_{B1}$ is determined by inserting $q^{Q,T}_{A1}$, $w^{Q,T}_{B1}$ into the first-order condition (4.14).

Comparing the outcomes in case of simple two-part tariffs and a quantity-price contract of supplier A, we get the following order of quantity levels.

Proposition 4.2 (Quantity-price contract versus simple two-part tariff). *The negotiated quantity $q^{Q,T}_{A1}$ is larger than $q^{T,T}_{A1}$ and the quantity level of B, $q^{Q,T}_{B1}$, is smaller than $q^{Q,Q}_{B1}$ if only supplier A chooses a quantity-price contract; $q^{Q,T}_{A1} > q^{T,T}_{A1} = q^{T,T}_{B1} > q^{Q,Q}_{A1} = q^{Q,Q}_{B1} > q^{Q,T}_{B1}$.*

The proof is delegated to the appendix, section 4.6.

The dynamic advantage of supplier A, given by the quantity-price contract, leads to a larger quantity level of good A, and a smaller one of good B compared to the symmetric contract combinations. Hence, a quantity-price contract offered only by supplier A restricts supplier B in its efficiency progress, but ensures a larger efficiency enhancement for supplier A.

Market-share contract of supplier A

Supplier A could also offer a market-share contract. In this case, the supplier and the downstream firm R negotiate the market-share level $\rho_{A1} = \frac{q_{A1}}{q_{A1}+q_{B1}}$ besides the quantity level q_{A1}, the wholesale price w_{A1} and fixed fee F_{A1}. Here, the supplier has maximum influence on the quantity choice of downstream firm R. That is, R would negotiate both quantity levels, respectively q_{A1} and q_{B1}, with supplier A. The quantity decision in stage 2 is eliminated.

As the quantity choice is made by supplier A and downstream firm R, the negotiation of supplier B and downstream firm R yields $w^{M,T}_{B1} = c_B$, and $F^{M,T}_{B1}$ according to

$$\begin{aligned}&\beta_B(\Pi_B(q_{A1}, w_{A1}, \rho_{A1}, w_{B1}, F_{B1}) - \pi^*_{B2}(c^{(A)}_{A2}, c_B))\\ &\quad = (1-\beta_B)(\Pi_R(q_{A1}, w_{A1}, \rho_{A1}, F_{A1}, w_{B1}, F_{B1}) - \Pi^{(A)}_R).\end{aligned}$$

Supplier A and downstream firm R negotiate quantities q_{A1}, q_{B1} (respectively q_{A1} and ρ_{A1} with $\frac{1-\rho_{A1}}{\rho_{A1}} q_{A1} = q_{B1}$), w_{A1} and F_{A1} according to

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{A2}} = 0, \tag{4.17}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - w^{M,T}_{B1} - \lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} = 0, \tag{4.18}$$

$$\begin{aligned}&\beta_A(\Pi_A(q_{A1}, w_{A1}, \rho_{A1}, F_{A1}, w_{B1}) - \pi^*_{A2}(c_A, c^{(B)}_{B2}))\\ &\quad = (1-\beta_A)(\Pi_R(q_{A1}, w_{A1}, \rho_{A1}, F_{A1}, w_{B1}, F_{B1}) - \Pi^{(B)}_R).\end{aligned} \tag{4.19}$$

Supplier B has no influence on quantities. Supplier A and downstream firm R achieve the outcome that maximizes their cumulated payoffs. That is, the market-share contract means an even larger advantage for supplier A than a quantity-price contract. Market-share contracts also change the market structure. Suppliers are Stackelberg competitors, as in case of a quantity-price contract.[16]

Proposition 4.3 (Market-share contract versus quantity-price contract).
In case of a market-share contract chosen by supplier A, the quantity level q_{B1} of rival supplier B is smaller or equal to the quantity level in case of a quantity-price contract chosen by supplier A, $q_{B1}^{M,T} \leq q_{B1}^{Q,T}$.

The proof is delegated to the appendix, section 4.6.
A market-share contract has maximum influence on the quantity choice of downstream firm R. It prescribes both quantity levels. Therefore, competition is hampered. Supplier A and downstream firm R negotiate quantities considering only their joint long-run payoff. In particular, they do not bear in mind the industry-profit increasing effect of a larger sales level of good B.

Proposition 4.3 shows that the quantity of good B is especially low. Learning effects of supplier B, respectively its efficiency gains, are more severely restricted by a market-share based contract than by a quantity-price contract.

Corollary 4.2 (Restriction of rivals).
Suppose that only one supplier (J) can choose a contract type and the other supplier negotiates a simple two-part tariff. Then, if supplier J chooses a quantity-price contract or a market-share based contract, the rival supplier is partially excluded from the market. Its output, respectively its efficiency gain, is restricted by both, a quantity-price contract and a market-share contract negotiated by supplier J.

Depending on the parameter constellation, the difference in second-period

[16] One could also introduce the case where supplier A chooses a market-share contract specifying only ρ_{A1} besides w_{A1} and F_{A1}. In this case, the negotiation between B and R has an impact on the outcome because the downstream firm chooses aggregate quantity according to both wholesale prices and ρ_{A1}. A smaller wholesale price w_{B1} increases both quantity levels proportionately. Supplier B and downstream firm R would set a wholesale price lower than marginal costs to achieve a relatively larger output and thus improve their learning effects. A comparison of the resulting outcome and the ones of the rest of the contract combinations requires a lot of specifications and is therefore left out.

marginal costs could be relatively large. In that case, a quantity-price contract and a market-share contract could exclude the rival supplier in period two (dynamic foreclosure). Additionally, it is not ruled out that quantity-price contracts or market-share contracts, used by one supplier only, could exclude the rival supplier in the first period. The reason lies in the Nash-in-Nash concept. Due to the bilateral negotiations, the supplier and downstream firm only consider their own payoffs and do not consider the rival supplier's payoffs.[17] Therefore, exclusion of the second supplier could occur, but would be an unintended result caused by the bilateral negotiations, because the most profitable (but not achievable) case is maximizing industry profits. For this reason, we concentrate on the case where both suppliers are active, at least in period one.

4.3.2.3 Strategic decisions and implications

In the previous sections, the focus has been set on the impact of the specific contract combinations on competition and on the efficiency gains of supplier A as well as its rival B. For symmetric strategies, we were able to completely solve the model.

Allowing for asymmetric strategies as well, the decision of suppliers in stage 0 cannot be solved for in the general setting. For this reason, we introduce the linear demand system mentioned in section 4.2.

Following the previous calculations, the linear demand system can be inserted into the conditions that achieve the equilibrium contractual terms and outcome. Here, some parameter specifications are necessary to ensure positive quantities in period one. In particular, we set the learning parameter equal to $\lambda = \frac{1}{5}$. This specification does not lead to a qualitative change regarding the order of quantities. To observe only positive quantity levels (at least for the case of simple two-part tariffs) we have to restrict the degree of substitution, $\gamma \in (0, \frac{7}{10})$. This specification allows for a comparison of the quantity levels regarding the bargaining power as well as the initial marginal cost level.

Corollary 4.3 (When only one supplier chooses a contract type (dominance))**.** *Suppose that one supplier can choose a contract type while the rival supplier is*

[17] The problem is caused by the Nash-in-Nash concept, especially by the fact that the agents, that negotiate for the downstream firm, do not fully consider the impact of the other agent's negotiation.

restricted to simple two-part tariffs. If both suppliers are equally efficient and have similar bargaining power vis-à-vis the downstream firm ($c_A = c_B$ and $\beta_A = \beta_B$) it can be more profitable for the strategic supplier to use a quantity-price contract than a market-share based contract.

In these cases, simple-two-part tariffs are preferred to the quantity-price contract from a social welfare point of view. The market-share contract would be even worse.[18]

Assuming that dominance is only a matter of contract choice, corollary 4.3 shows that a quantity-price contract might be a better choice than a market-share contract for the dominant supplier. That is, the contract that specifies less instruments is preferred to a contract type that has more contractual terms and has therefore more influence on the outcome. The intuition for this result stems from the bargaining situation. If the dominant supplier uses a market-share contract, it specifies both quantity levels, q_{A1} and q_{B1}, in the negotiation with the downstream firm. The quantity levels that are chosen maximize cumulated payoffs of the supplier and downstream firm R. However, the second-period payoffs of the rival supplier, hence the impact of learning on the rival's payoffs, and therefore on industry payoffs, are not considered. Hence, the outcome achieves large efficiency gains for the supplier offering the market-share contract, and drastically restricts the efficiency gains of the rival supplier. To the contrary, in the industry-profit maximizing case, both suppliers produce quantity levels $q^I_{At} = q^I_{Bt}$ because they are equally efficient. The large difference between quantity levels in case of a market-share contract are thus not desirable.

In case of a quantity-price contract, the supplier that offers the contract type and the downstream firm also intend to maximize their cumulated payoffs. Yet, the rival supplier's negotiation with the downstream firm, in particular the wholesale price, has an influence on the quantity decision of the downstream firm. The simple two-part tariff of the rival supplier offers an opportunity to react on the quantity-price contract of the dominant supplier. Therefore, the difference between quantity levels $q^{Q,T}_{A1}$, $q^{Q,T}_{B1}$ is smaller than the difference between $q^{M,T}_{A1}$ and $q^{M,T}_{B1}$. Hence, a quantity-price contract can be more profitable than a market-share contract if suppliers are equally efficient.

[18]It can be shown that in case of a linear demand system, the difference in second-period marginal costs never grows such that supplier B is excluded in period 2.

Next, we consider the case where both suppliers can choose (different) contract types. In this scenario, both suppliers could offer a simple two-part tariff or a quantity-price contract.[19]

Corollary 4.4 (When both suppliers choose contract types)**.**
If both suppliers simultaneously choose contract types, they both decide to negotiate a quantity-price contract. This contract combination leads to maximum profits compared to the further contract combinations. From a social welfare point of view, simple two-part tariffs are preferred to the case where both suppliers negotiate quantity-price contracts.

In a model with equally efficient suppliers, the quantity-price contract represents the strictly dominant contractual strategy (in stage 0). A rival supplier will use a quantity-price contract to defend its market share if it is able to choose contract types. For the present constellation of assumptions, a ban on market-share contracts does not influence the outcome because market-share contracts are unprofitable. In contrast, a ban on quantity-price contracts would increase social welfare.

The comparisons of quantities, long-run profits and social welfare are best explained on the basis of graphs. Here, we present the results for specific parameters. The results shown below are qualitatively similar to the ones of the other assumed parameter constellations.

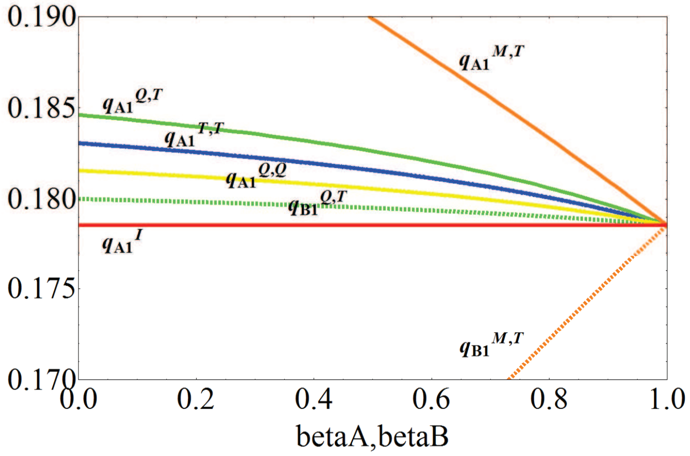
4.3.2.4 Numerical example

We consider the parameter constellation $\lambda = \frac{1}{5}$, $\gamma = \frac{1}{2}$, $c_A = c_B = \frac{1}{2}$. In this case, the quantity levels, joint profits and social welfare functions are depicted in figure 4.2.

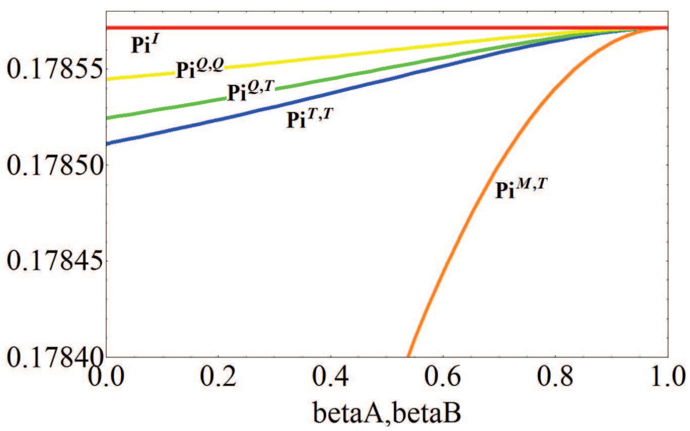
The first graph, figure 4.2(a), illustrates the quantity levels in case of the assumed contract combinations, depending on bargaining power $\beta = \beta_A = \beta_B$.[20] If β equals one, the downstream firm has all bargaining power. Therefore, the downstream firm

[19] A market-share contract cannot be regarded in this scenario due to the strategy sets in stage 0 of the game.

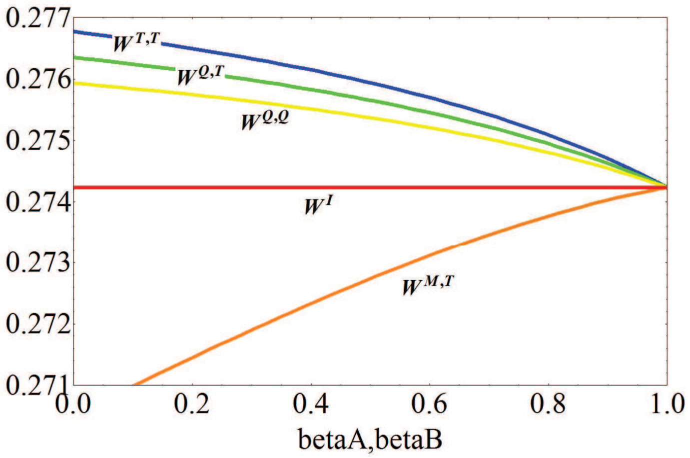
[20] Red is chosen for the industry profit maximum, blue illustrates simple two-part tariffs (T,T), yellow quantity-price contracts (Q,Q), green illustrates the case with one quantity-price contract (Q,T) and orange the case with a market-share contract (M,T).



(a) Quantity levels q_{A1}, q_{B1}.



(b) Long-run joint profits.



(c) Social welfare.

Figure 4.2: Quantities, joint profits and social welfare in case of $\lambda = 0.2$, $\gamma = 0.5$, $c_A = c_B = 0.5$, and $\beta_A = \beta_B$.

earns the industry payoffs minus the constant outside options of suppliers A and B. That is, the downstream firm maximizes industry profits and all outcomes converge to the joint-profit maximizing outcome for $\beta \to 1$. If, in contrast, β is close to zero, the upstream firms have all bargaining power and set take-it-or-leave-it offers. In this case, the outcomes of the different scenarios vary the most.

The graph reflects the results about the order of sales levels analyzed above. In addition, it depicts the quantitative differences between the quantity levels and therefore facilitates the comparison with regard to profits and social welfare.

First, the quantity levels in case of two-part tariffs (T,T) are larger than in case of quantity-price contracts (Q,Q) and these are larger than the industry-profit maximizing levels (I). Furthermore, the quantity level of A equals the quantity level of B in all these cases. As a result, profits are larger in case of (Q,Q) than in case of (T,T). To the contrary, social welfare is smaller in case of (Q,Q) than in case of (T,T).[21]

Second, the comparison of the contract combinations in case of a dominant supplier is feasible. Figure 4.2(a) shows that $q_{A1}^{Q,T}$ is larger than $q_{A1}^{T,T}$ and $q_{B1}^{Q,T}$ is smaller than $q_{B1}^{Q,Q}$ (proposition 4.2). That means, the difference between supplier A and supplier B's sales due to Stackelberg competition is visible. The difference is not as large as in case of a market-share contract of supplier A. In that case, $q_{A1}^{M,T}$ is even larger than $q_{A1}^{Q,T}$ and $q_{B1}^{M,T}$ is extremely smaller than $q_{B1}^{Q,T}$. On the one hand, supplier B is thus more probably excluded by supplier A's market-share contract in period two than by A's quantity-price contract. The difference in first-period quantities is larger, and therefore the difference in marginal costs. On the other hand, the aggregate quantity is smaller in case of a market-share contract than in case of a quantity-price contract. Regarding profits and social welfare, a quantity-price contract can consequently be more profitable and will be socially more desirable than a market-share contract.

That means that the supplier choosing contract types will not necessarily use the contract type with the largest number of instruments, which has the most influence on the quantity choice of the downstream firm (and rival supplier). In the given context, the market-share contract is rather harmful. The reason stems from the fact that supplier A and downstream firm R choose quantities with respect to their joint payoffs, and do not consider the rival supplier's benefits caused by

[21] Note that the maximum social welfare for the given parameter constellation is 0.384615.

inter-temporal effects, π^*_{B2}. From the producers' point of view, the quantity-price contract is more profitable than the market-share contract. From a social welfare point of view, the quantity-price contract is also better than the market-share contract because quantity levels $q^{Q,T}_{A1}$, $q^{Q,T}_{B1}$ do not differ as drastically as $q^{M,T}_{A1}$, $q^{M,T}_{B1}$, and the aggregate quantity is larger in case of (Q,T).

In the third scenario, the contract combinations (T,T), (Q,T) and (Q,Q) have to be considered. Comparing one (Q,T) and two (Q,Q) quantity-price contracts, figure 4.2(b) shows that the contract combination with both suppliers using quantity-price contracts is more profitable. The reason is that the externality regarding the quantity choice of the downstream firm, due to learning-by-doing, is eliminated when both suppliers negotiate quantity-price contracts. Moreover, this means that if both suppliers can choose contract types, they would use quantity-price contracts and nobody would be (partially) excluded. Rather, the rival supplier can defend its market share by negotiating a quantity-price contract.

However, from a social point of view, one quantity-price contract would be better than two. The reason is similar to the one above. As quantity-price contracts eliminate externalities of the downstream firm's quantity choice, and as the downstream firm prefers larger quantity levels, the average efficiency gains are larger when only one supplier chooses a quantity-price contract than when both use these contract types. In sum, a quantity price contract lowers social welfare, compared to the case where all firms negotiate two-part tariffs. Two quantity-price contracts further lower social welfare.

4.4 Asymmetric suppliers

In this section, we use the linear demand specification and parameter constellation from above, but allow for differences in bargaining power and initial marginal costs of suppliers A and B. That is, we allow for asymmetric suppliers where we suppose that the more efficient supplier is the dominant firm.

First, suppose that $\beta_A < 1$ and $\beta_B = 1$. It means that supplier B has no bargaining power. Supplier A, the dominant supplier, has bargaining power vis-à-vis the downstream firm. In this case, the rival supplier B has zero second-period profits. The downstream firm R considers the joint second-period payoffs of B and R

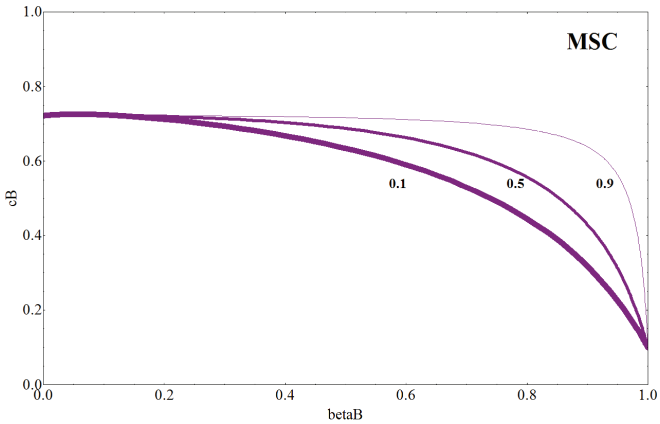
in its quantity decision. Then, a market-share contract between supplier A and downstream firm R will lead to maximum industry profits. The reason is that the externality of the second supplier negotiating with downstream firm R is eliminated, and the externality caused by the quantity decision of the downstream firm is influenced by a market-share contract.[22]

Second, when both suppliers have at least some bargaining power vis-à-vis the downstream firm, the contract choice depends on the difference between the bargaining powers β_A, β_B and the initial marginal costs $c_{_A}$, $c_{_B}$. Allowing for cost differences and/or differences in the bargaining power when parameters λ and γ are equal to the specification in section 4.3.2.3, we can show that the contract decision of a dominant supplier (in stage 0) changes.

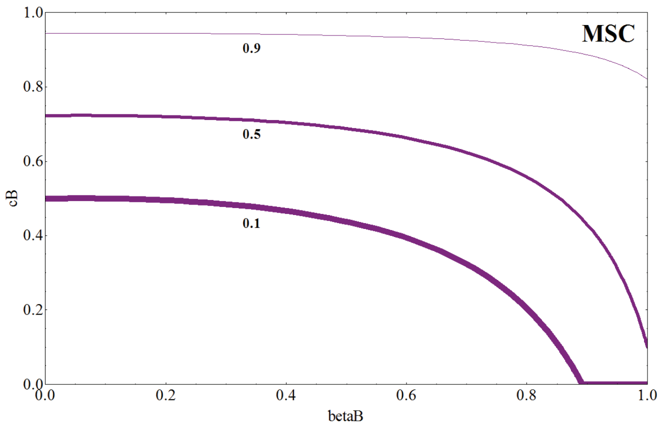
Figure 4.3 shows the combinations where market-share contracts are more profitable for supplier A than the other contract types. In the areas above the illustrated functions, market-share contracts are more profitable for a dominant supplier than other contract types. In figure 4.3(a), it is shown that if the bargaining power β_A increases, the number of parameter constellations $(\beta_B, c_{_B})$ where market-share contracts are preferred by the dominant supplier decreases. A large β_A means a relatively low bargaining power of supplier A vis-à-vis the downstream firm. That is, the larger β_A, the lower its long-run payoffs and the lower is the probability that a market-share contract maximizes A's long-run profits. Figure 4.3(b) shows that a lower marginal cost level of the dominant supplier increases the probability that a market-share contract is profitable for the dominant supplier. In general, one can see that, for the given parameters λ, γ and optionally $c_{_A}$ or β_A, only for a relatively large difference in marginal costs $c_{_A}$, $c_{_B}$ and/or a relatively large difference between β_A and β_B, a market-share contract could be profitably used. This finding holds for further parameter constellations.

The reason why market-share contracts are more profitable in these cases lies in the fact that the rival supplier is smaller than the dominant supplier. In the industry profit maximum, the quantity of the rival supplier is smaller than the quantity of the dominant supplier. The quantities $q_{_{A1}}$, $q_{_{B1}}$ in case of a market-share contract of the dominant supplier can hence be closer to the industry profit maximum than in case of equally efficient suppliers. It can thus be more profitable for the dominant supplier to use a market-share contract compared to the further contract types.

[22] The result is independent of parameter constellations. It holds for the general demand system.



(a) $c_A = 0.5$ and $\beta_A \in \{0.1, 0.5, 0.9\}$.



(b) $c_A \in \{0.1, 0.5, 0.9\}$ and $\beta_A = 0.5$.

Figure 4.3: Representation of the parameter constellations where a dominant supplier prefers market-share contracts, with $\lambda = 0.2$, $\gamma = 0.5$.

In sum, the asymmetric structure shows that market-share contracts might be more profitable for an upstream firm, that has additional advantages over its rival (not only due to the contract choice). When a supplier is more efficient or has a larger bargaining power vis-à-vis the downstream firm than the rival supplier, our calculations confirm the use of market-share contracts. In addition, social welfare is smaller than in other contract cases. That is, the market-share contract used by a more efficient supplier is socially less desirable than quantity-price contracts or standard two-part tariffs.

4.5 Conclusion

This essay investigates the contract choice of upstream competitors in a dynamic market. In a two-period model, two upstream firms simultaneously negotiate short-term contracts with a common buyer. The contract types that can be negotiated range from simple two-part tariffs, over quantity-price contracts to market-share contracts. The model allows us to study the impact of the contract choice of suppliers on upstream competition, the dynamic market structure and efficiency.

Our first and basic result is that as long as a market is characterized by inter-temporal externalities, the industry-profit maximizing outcome cannot be reached, independent of the contract types that could be chosen. The reason lies in the fact that the multi-person Nash equilibrium is never similar to the case of bilateral negotiations between the upstream and downstream firms.

The considered contract combinations lead to different outcomes. In addition, a specific contract combination can be more profitable than another one, depending on parameter constellations.

In particular, we show that if suppliers are equally efficient and have the same strategic opportunities, they will choose quantity-price contracts instead of further contract types. The symmetric equilibrium is more profitable for the firms than offering simple two-part tariffs. In addition, the symmetric contract choice leads to larger profits than the case where only one supplier offers a quantity-price contract. In this way, our results demonstrate that in case of learning effects, equally efficient suppliers have an incentive to specify contract terms, but do not use specific contract types to exclude their (strategic) rival. However, the contract specifications chosen by the strategic suppliers dampen competition. Efficiency gains are smaller than in the standard setting and social welfare is harmed by the contract choice of the suppliers. By this means, our results point out that the contract choice of equally efficient upstream firms in case of inter-temporal externalities may harm consumer surplus and social welfare.

If only one supplier uses a quantity-price contract or a market-share contract while the second supplier negotiates simple two-part tariffs, we find that the use of specified contract terms creates an advantage for the firm using this contract. Therefore, a situation of Stackelberg competition occurs. The dynamic advantage due to the contract choice leads to a partial exclusion of the rival and could, depending on the specifications, lead to full exclusion in the dynamic context (for example in the second period).

When upstream firms are nearly equally efficient and have nearly the same bargaining power, we show that the supplier with contractual flexibility might prefer quantity price contracts to market-share contracts. This result implies that it is not generally desirable for a strategic firm to use a contract with especially many instruments. In contrast, market-share contracts characterize an over-specification of parameters.

Our model contributes to the literature by analyzing further market situations in which specific market participants use market-share contracts or contracts that refer only to the own quantity. We show that contract specifications are used to increase joint payoffs of all firms, and are not generally applied to exclude a rival supplier. If a rival supplier is nevertheless (dynamically) excluded from the market, this exclusion is unintended and is caused by externalities that are induced by the bargaining structure. To this end, our model presents additional reasons for the specific contract choice of upstream suppliers and shows that even though the intention of contract specifications is not due to exclusionary reasons, consumer surplus and social welfare might be harmed by the applied contract terms.

4.6 Appendix

Second-period payoffs are given by

$$\begin{aligned}
\pi_{A2} &= \frac{1-\beta_A}{1-(1-\beta_A)(1-\beta_B)}(\beta_B\pi_2^I + (1-\beta_B)\pi_{R2}^{(A)} - \pi_{R2}^{(B)}),\\
\pi_{B2} &= \frac{1-\beta_B}{1-(1-\beta_A)(1-\beta_B)}(\beta_A\pi_2^I + (1-\beta_A)\pi_{R2}^{(B)} - \pi_{R2}^{(A)}),\\
\pi_{R2} &= \frac{1}{1-(1-\beta_A)(1-\beta_B)}(\beta_A\beta_B\pi_2^I + \beta_A(1-\beta_B)\pi_{R2}^{(A)} + \beta_B(1-\beta_A)\pi_{R2}^{(B)})
\end{aligned}$$

where

$$\begin{aligned}
\pi_{R2}^{(A)} &= \beta_A(P_A(q_{A2}^{(A)}(c_{A2}),0) - c_{A2})q_{A2}^{(A)}(c_{A2}),\\
\pi_{R2}^{(B)} &= \beta_B(P_B(0,q_{B2}^{(B)}(c_{B2})) - c_{B2})q_{B2}^{(B)}(c_{B2}).
\end{aligned}$$

The partial derivatives of second-period profits with respect to marginal costs are given by

$$\begin{aligned}
\frac{\partial\pi_{A2}}{\partial c_{A2}} &= \frac{1-\beta_A}{1-(1-\beta_A)(1-\beta_B)}(-\beta_B q_{A2}^I + (1-\beta_B)\beta_A(-q_{A2}^{(A)})) < 0,\\
\frac{\partial\pi_{A2}}{\partial c_{B2}} &= \frac{(1-\beta_A)\beta_B}{1-(1-\beta_A)(1-\beta_B)}(q_{B2}^{(B)} - q_{B2}^I) > 0,\\
\frac{\partial\pi_{B2}}{\partial c_{A2}} &= \frac{\beta_A(1-\beta_B)}{1-(1-\beta_A)(1-\beta_B)}(q_{A2}^{(A)} - q_{A2}^I) > 0,\\
\frac{\partial\pi_{B2}}{\partial c_{B2}} &= \frac{1-\beta_B}{1-(1-\beta_A)(1-\beta_B)}(-\beta_A q_{B2}^I - (1-\beta_A)\beta_B q_{B2}^{(B)}) < 0,\\
\frac{\partial\pi_{R2}}{\partial c_{A2}} &= \frac{1}{1-(1-\beta_A)(1-\beta_B)}(-\beta_A\beta_B q_{A2}^I - \beta_A^2(1-\beta_B)q_{A2}^{(A)}) < 0,\\
\frac{\partial\pi_{R2}}{\partial c_{B2}} &= \frac{1}{1-(1-\beta_A)(1-\beta_B)}(-\beta_A\beta_B q_{B2}^I - \beta_B^2(1-\beta_A)q_{B2}^{(B)}) < 0,
\end{aligned}$$

Notably, as long as goods are imperfect substitutes (i.e. $\gamma \in (0,1)$ excluding 0 and 1) and parameter constellations solve for positive second-period payoffs, there is no partial derivative that equals zero.

If the parameter constellations do not solve for positive second-period quantities for one supplier, the payoff of this firm is zero. The downstream firm and the active supplier split up maximum cumulated payoffs.

Proof of Proposition 4.1

Comparison of $q^{Q,Q}_{J1}$ and $q^{T,T}_{J1}$:
Assume that $q^{Q,Q}_{A1} = q^{T,T}_{A1} = q^{Q,Q}_{B1} = q^{T,T}_{B1}$. Then, $c^{Q,Q}_{A2} = c^{T,T}_{A2} = c^{Q,Q}_{B2} = c^{T,T}_{B2}$ and hence $q^{Q,Q}_{A2} = q^{T,T}_{A2} = q^{Q,Q}_{B2} = q^{T,T}_{B2}$.

Comparing the first-order conditions in case of simple two-part tariffs (4.4), (4.5) where $w_{A1} = w^{T,T}_{A1}$ and $w_{B1} = w^{T,T}_{B1}$ with these in case of quantity-price contract (4.10), (4.12) leads to a contradiction of the assumption. As long as $\alpha_1 = -\lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(w_{A1},w_{B1})/\partial w_{A1}}{\partial q_{A1}(w_{A1},w_{B1})/\partial w_{A1}}$ and $\alpha_2 = -\lambda \frac{\partial \pi^*_{B2}}{\partial c_{A2}} \frac{\partial q_{A1}(w_{A1},w_{B1})/\partial w_{B1}}{\partial q_{B1}(w_{A1},w_{B1})/\partial w_{B1}}$ are not zero, the quantities $q^{Q,Q}_{A1}$, $q^{Q,Q}_{B1}$ cannot be equal to $q^{T,T}_{A1}$, $q^{T,T}_{B1}$.

Moreover, the partial derivatives of the second-period payoffs are symmetric and positive (independent of the parameter constellations) if learning occurs. $\frac{\partial q_{B1}(w_{A1},w_{B1})/\partial w_{A1}}{\partial q_{A1}(w_{A1},w_{B1})/\partial w_{A1}}$ and $\frac{\partial q_{A1}(w_{A1},w_{B1})/\partial w_{B1}}{\partial q_{B1}(w_{A1},w_{B1})/\partial w_{B1}}$ are negative due to the implicit function theorem applied on (4.4), (4.5).

Note that α_1 and α_2 are positive. Therefore, quantities $q^{T,T}_{A1}$, $q^{T,T}_{B1}$ must be larger than $q^{Q,Q}_{A1}$, $q^{Q,Q}_{B1}$. For the case that second-period marginal costs $c^{Q,T}_{A2}$, $c^{Q,T}_{B2}$ do not differ drastically, we proof by contradiction. Suppose that $q^{Q,T}_{A1} = q^{T,T}_{A1} = q^{T,T}_{B1} = q^{Q,T}_{B1}$. The quantities of supplier A and B are equal in case of simple two-part tariffs because suppliers are symmetric and the wholesale prices are therefore similarly chosen.

Proof of Proposition 4.2

Comparison of Q,T and T,T:
When both cases (T,T and Q,T) solve for the same outcomes, we have $c^{Q,T}_{A2} = c^{T,T}_{A2} = c^{Q,T}_{B2} = c^{T,T}_{B2}$ and hence $q^{Q,T}_{A2} = q^{T,T}_{A2} = q^{T,T}_{B2} = q^{Q,T}_{B2}$. It is therefore concluded that $w^{Q,T}_{B1}$ and $q^{Q,T}_{A1}$ inserted into the first-order condition (4.14) have to lead to the same q_{B1} as $w^{T,T}_{B1}$ and $q^{Q,t}_{A1} = q^{T,T}_{A1}$. Yet, the first-order conditions (4.5) and (4.14) differ only in the wholesale prices, and $w^{T,T}_{B1} \neq w^{Q,T}_{B1}$.

In particular, $w^{T,T}_{B1} = c_B + \lambda \frac{\partial \pi^*_{B2}}{\partial c_{B2}}|_{w^{T,T}_{A1},w^{T,T}_{B1}} + \lambda \frac{\partial \pi^*_{B2}}{\partial c_{A2}}|_{w^{T,T}_{A1},w^{T,T}_{B1}} \frac{\partial q_{A1}(w_{A1},w_{B1})/\partial w_{B1}}{\partial q_{B1}(w_{A1},w_{B1})/\partial w_{B1}}|_{w^{T,T}_{A1},w^{T,T}_{B1}}$ would have to be smaller than $w^{Q,T}_{B1} = c_B + \lambda \frac{\partial \pi^*_{B2}}{\partial c_{B2}}|_{q^{Q,T}_{A1},w^{Q,T}_{B1}}$. By the implicit function theorem, it can be shown that $\frac{\partial q_{A1}(w_{A1},w_{B1})/\partial w_{B1}}{\partial q_{B1}(w_{A1},w_{B1})/w_{B1}}$ is always negative and supposed to be smaller than one. With $\frac{\partial \pi^*_{B2}}{\partial c_{A2}}$ being always positive (see partial derivatives), it means that $q^{Q,T}_{B1}$

cannot be larger than $q_{B1}^{T,T}$. Thus, $q_{B1}^{T,T}$ has to be larger than $q_{B1}^{Q,T}$ and $q_{A1}^{T,T}$ has to be smaller than $q_{A1}^{Q,T}$.

If second-period marginal costs $c_{A2}^{Q,T}$ differ so much that supplier B is not active in period 2, we get the same order of quantities, at least for a linear demand system.

Comparison of $q_{J1}^{Q,Q}$ *and* $q_{J1}^{Q,T}$*:*
When only supplier A uses a quantity price contract, $w_{B1}^{Q,T}$ and $q_{A1}^{Q,T}$ are given by (4.16), (4.15), and $q_{B1}^{Q,T}$ by inserting these into (4.14).

When both suppliers negotiate quantity-price contracts, the first-order conditions are given by (4.10), (4.12).

Let us assume that the quantity levels are equal for both cases. Then, in a similar way to the mentioned comparisons, we contradict this assumption. Namely, (4.15) cannot lead to the same q_{A1} as (4.10). Instead, as $-\lambda \frac{\partial \pi_{A2}^*}{\partial c_{B2}} \frac{\partial q_{B1}(q_{A1}, w_{B1})}{\partial q_{A1}}$ is positive in (4.15), we have $q_{A1}^{Q,T} > q_{A1}^{Q,Q} = q_{B1}^{Q,Q} > q_{B1}^{Q,T}$.

Proof of Proposition 4.3

We note the proofs for the case that marginal costs $c_{A2}^{Q,T}$, $c_{B2}^{Q,T}$, and $c_{A2}^{M,T}$, $c_{B2}^{M,T}$ are such that both suppliers are active in period 2.
The outcome in case of a market-share based contract of supplier A is given by equations (4.17), (4.18). In case of a quantity-price contract of supplier A, $q_{A1}^{Q,T}$ and $w_{B1}^{Q,T}$ are given by (4.15), (4.16). $q_{B1}^{Q,T}$ is determined by inserting $q_{A1}^{Q,t}$ and $w_{B1}^{Q,T}$ into (4.14).

If second-period marginal costs will differ so much that it is not profitable for supplier B to stay in the market, then both contract types lead to the same outcome as $\frac{\partial \pi_{A2}^*}{\partial c_{B2}} = \frac{\partial \pi_{B2}^*}{\partial c_{B2}} = \frac{\partial \pi_{B2}^*}{\partial c_{B2}} = \frac{\partial \pi_{B2}^*}{\partial c_{A2}} = 0$.

If second-period marginal costs will not be drastically different, we introduce the varied system

$$\frac{\partial P_A}{\partial q_{A1}} q_{A1} + \frac{\partial P_B}{\partial q_{A1}} q_{B1} + P_A(q_{A1}, q_{B1}) - c_A - \lambda \frac{\partial \pi^*_{R2}}{\partial c_{A2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{A2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(q_{A1}, w_{B1})}{\partial q_{A1}} |_{\{q^{Q,T}_{A1}, w^{Q,T}_{B1}\}} = 0, \tag{4.20}$$

$$\frac{\partial P_A}{\partial q_{B1}} q_{A1} + \frac{\partial P_B}{\partial q_{B1}} q_{B1} + P_B(q_{A1}, q_{B1}) - c_B - \lambda \frac{\partial \pi^*_{R2}}{\partial c_{B2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(q_{A1}, w_{B1})}{\partial q_{A1}} |_{\{q^{Q,T}_{A1}, w^{Q,T}_{B1}\}} = 0. \tag{4.21}$$

First, the varied system presents a variation to (4.17), (4.18) because in each first-order condition we added the constant term $-\lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(q_{A1}, w_{B1})}{\partial q_{A1}} |_{\{q^{Q,T}_{A1}, w^{Q,T}_{B1}\}}$. This term is positive because the partial derivative of second-period payoffs π^*_{A2} is positive and $\frac{\partial q_{B1}(q_{A1}, w_{B1})}{\partial q_{A1}}$ is negative, following the implicit function theorem on (4.14). In addition, we assumed that the absolute value of the last term is smaller than one.

Due to these reasons, the varied system yields larger quantities q^{var}_{A1}, q^{var}_{B1} than the initial system, that is $q^{var}_{A1} > q^{M,T}_{A1}$, $q^{var}_{B1} > q^{M,T}_{B1}$.

Now, let us compare the outcome of the varied system and the outcome of a quantity-price contract of supplier A (and a simple two-part tariff of B). In analogy to the previous comparisons, we may suppose that the quantity levels are equal in both cases. Then, as $-\lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} - \lambda \frac{\partial \pi^*_{A2}}{\partial c_{B2}} \frac{\partial q_{B1}(q_{A1}, w_{B1})}{\partial q_{A1}} |_{\{q^{Q,T}_{A1}, w^{Q,T}_{B1}\}}$ is negative and $-\lambda \frac{\partial \pi^*_{B2}}{\partial c_{B2}} |_{\{q^{Q,T}_{A1}, w^{Q,T}_{B1}\}}$ (see $w^{Q,T}_{B1}$, inter alia (4.16)) is positive, $q^{var}_{B1} < q^{Q,T}_{B1}$ and $q^{var}_{A1} > q^{Q,T}_{A1}$.

We get $q^{Q,T}_{B1} > q^{M,T}_{B1}$. A comparison of $q^{Q,T}_{A1}$ and $q^{M,T}_{A1}$ is not possible with a general demand system. With a linear demand system, we get $q^{Q,T}_{A1} < q^{M,T}_{A1}$.

Chapter 5

Concluding Remarks

In this thesis, we analyzed the contractual decision of firms in a dynamic vertical structure. Our results show that the consideration of dynamic effects as, for example, learning-by-doing or, in a similar way, consumption externalities, does have an influence on the contractual choice of suppliers and therefore on outcome, competition, efficiency gains and welfare. In this way, the present analysis confirms that considering a dynamic view on allegedly abusive conduct, as for example in case of specific CRRs, could have an influence on the legal decision of antitrust authorities.

In particular, we show that specific contract types, namely market-share contracts but also quantity-price contracts are profitably used in case of learning effects and would not necessarily be applied in cases without inter-temporal effects.

The first model offers insights about why a dominant supplier could use market-share contracts instead of simpler contract types. The reason is that the learning effects of a rival supplier cause an externality in the downstream market. Market-share contracts can influence the downstream firm's strategy and eliminate the externality. As contract terms contain a fixed fee, the dominant supplier is able to shift rents. Consequently, the contract choice of the dominant supplier is not used to exclude the rival supplier, but to achieve the collusive outcome. Nevertheless, it is shown that the efficiency gains of the rival (induced by learning effects) are reduced. Therefore, market-share contracts lead to partial exclusion of the rival.

The second model proves that the former result even holds for the case of strategic suppliers, whereby the dominant supplier has a temporal advantage over its rival. In contrast to the first model, it is not necessarily given that the rival supplier's efficiency gains are restricted by the profitable contract choice of the dominant supplier. Depending on buyer power, the dominant supplier's contractual agreement with the downstream firm could enhance the rival's efficiency because of the rent-shifting effect of the contracts.

The third model allows for simultaneous negotiations of both suppliers. It shows that suppliers might benefit more from the use of quantity price contracts instead of market-share contracts. This result can additionally explain that upstream firms prefer quantity-price contracts to more specified contract types, as for example market-share contracts depending on the model assumptions. Moreover, the specification of contractual conditions influences the kind of competition whenever learning-by-doing occurs.

In view of the ongoing competition policy debate on these vertical agreements, our models present that a more economic approach might lead to a modified, more comprehensible assessment. However, we show that the specific outcomes depend on the market structure and market-specific parameters, as for example bargaining power besides costs. Furthermore, we are aware that additional assumptions, specifically the introduction of asymmetric information, may change the outcomes and may lead to further findings. As a consequence, our results do not aim to find a legal standard that is easier to handle, but call attention to consider market dynamics in cases where they appear to be reasonable.

This thesis sheds further light on the non-negligible influence that inter-temporal externalities, in particular learning effects, have on the pricing strategies in vertical structures and their consequences.

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