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Doctoral Thesis

Pricing And Regulation In Multi-sided Markets - Implications for Payment Card Networks And Smart Metering

Suggested Citation: Uhlenbrock, Jens (2012) : Pricing And Regulation In Multi-sided Markets - Implications for Payment Card Networks And Smart Metering, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel, Hamburg

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PRICING AND REGULATION IN MULTI-SIDED MARKETS

Implications for Payment Card Networks and Smart Metering

Dissertation

Zur Erlangung des akademischen Grades
doctor rerum politicarum



eingereicht an der EBS Universität für Wirtschaft und Recht
Department of Governance and Economics
Wiesbaden

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AWARDS

A version of chapter 4 of this thesis has been awarded the Dennis J. O'Brien Student Paper Award at the 30th annual USAEE/IAEE North American Conference on Redefining the Energy Economy: Changing Roles of Industry, Government and Research.

Wisdom is not the purchase of a day,
and it is no wonder that we should err at the first setting off.

— Thomas Paine

ACKNOWLEDGMENTS

The thesis at hand has undergone fundamental change from its inception in 2007. Not only its theoretical models and the qualitative analysis have experienced thorough revisions and numerous iterations—letting me err many times over rather than simply at the first setting off—, but also its main focus has shifted. Without the endless professional and moral support of several people this thesis could not exist in its current form.

First and foremost, I want to thank my supervisor, Dominique Demougin. Not only for putting his faith in me to complete this thesis, but also for his advice, endless support, and available time. Several glasses of wine have been well invested over many evenings trying to calibrate the models sensibly. He truly is a researcher by vocation. Also, I want to thank Michael Hüther for giving me the opportunity to learn beyond the mere scope of this thesis, providing access to a variety of valuable research and entrusting me with its structured presentation. In his own daily work he exemplifies the exalted requirements of his general principles. Further, I want to thank Benjamin Bental for his valuable support and advice. He was always readily available when I needed his help.

At the chair, I especially want to thank Clemens Buchen and Jenny Kragl. Having gone through the doctoral process with Dominique themselves, they were always eager to share insights, give advice, and offer moral support. Their critical eyes have improved several earlier versions of this manuscript. Even more importantly, they established a work environment that was more than just work and that I will always fondly remember. With Clemens, I furthermore share common literary interests and greatly availed myself of his broad erudition.

I also want to thank my two co-authors. First, Markus Langlet, who introduced me to the theory of multi-sided markets and without whom this thesis would have turned out much different. Working with him was a real pleasure and set me off in a completely new direction. Second, Jan Schächtele, with whom it had already been fun studying, proved to be a formidable co-author as our respective strengths markedly complement each other's. It was a great pleasure working together with a friend and I tremendously benefited from his prior work experience as well as from his many critical revisions of my writing.

Last but definitely not least, I am grateful to my family and to Sabine for their unconditional love and support, which sometimes appears banal for it has never lacked, but which is truly the foundation that everything else builds upon.

I am much indebted to everyone mentioned here as well as to several other persons not mentioned, who have contributed to this thesis in smaller ways. Unnecessary to say, all misinterpretations, errors, and omissions remain my own.

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ACRONYMS

AMI	Advanced Meter Infrastructure
BBC	British Broadcasting Corporation
DECC	Department of Energy and Climate Change
DSO	Distribution System Operator
EnWG	Energiewirtschaftsgesetz (Energy Industry Act)
EU	European Union
f.o.c.	First Order Condition
GDP	Gross Domestic Product
ISO	Independent System Operator
IP	Internet Protocol
IT	Information Technology
kWh	Kilowatt hour
OFGEM	Office of Gas and Electricity Markets
PIN	Personal Identification Number
Rabobank	Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A.
RTO	Regional Transmission Organization
SEPA	Single Euro Payments Area
SNS	Samenwerkende Nederlandse Spaarbanken
TSO	Transmission System Operator
UK	United Kingdom
US	United States (of America)

Part I

PRELIMINARY

THE CONTEXT

1.1 INTRODUCTION

The phenomenon of multi-sided markets has attracted significant academic interest over the last two decades. Even though these types of businesses have existed for a long time, researchers only began to investigate their peculiarities thoroughly in the mid-1990s. The probable reason for this quite recent emergence of interest is the fact that technological developments, such as the internet, have exacerbated the importance of network effects, which are a major force behind multi-sided markets. Consequently, businesses that operate in multi-sided markets, such as Google, Facebook, or Visa, play a more essential role in today's society. In these markets, firms employ distinct pricing strategies that observers are sometimes struggling to comprehend even today. While market participants are trying to exploit these novel opportunities, regulators and academics all over the world are discussing the economical impact of multi-sided markets.

In a multi-sided market, a platform needs to serve two or more distinct customer groups to function at all, and the value of that platform to at least one customer group has to depend on the actions and/or the number of participants on the other side (Evans, 2009). A classic example of a multi-sided market is the newspaper (or magazines). A simple schematic depiction of this market can be seen in Figure 1.1. Newspaper revenues are comprised of subscription payments from readers as well as advertising fees paid for space in the publications by other businesses. Readers exhibit indirect network effects toward advertisers. This means that the value of each advertisement, and thus the price that can be charged for it, increases with the number of readers of the newspaper (Evans & Schmalensee, 2008). In the other direction—from advertisers to readers—, however, there are probably no indirect network effects in this example. The value of a publication for the reader seldom increases with the number of advertisements in it.

Publishers, therefore, have to strike the right balance between charging the reader and charging for ad space (Ferguson, 1983). In other words, it is not only relevant how much one can charge (the price level) but also who to charge (the price structure). For different newspaper contents and different target groups, this price balancing act may result in substantially varying pricing models. Some newspapers (e.g. publishing regional real estate offerings) may be distributed free of charge and be paid for by realtors who are promoting their offers;

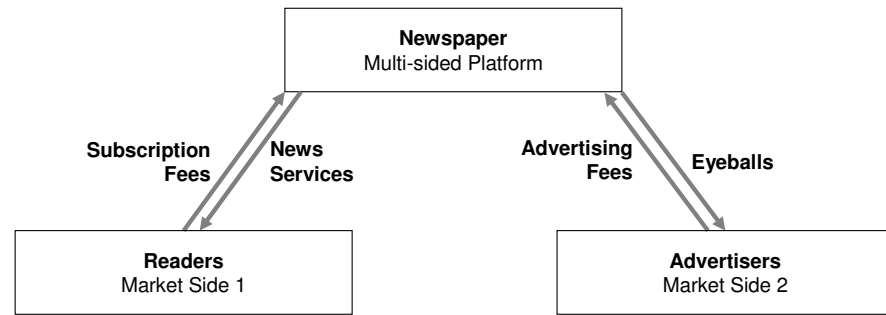


Figure 1.1: Interactions of a newspaper from a multi-sided market perspective.

on the other hand, political newspapers may limit ad space to be able to demonstrate journalistic independence and make money through subscription revenues. The first example of offering readers material service free of charge demonstrates a common outcome of multi-sided markets (Jullien, 2001); often one side of the market receives the service below its true marginal costs—even if the platform operator is a monopolist (Blair & Romano, 1993). This market side exhibits indirect network effects. Its presence adds significant value to the other market side(s), which have to pay for the privilege of interacting with them.

In some contexts, this practice may seem unfair. On the grounds of eliminating gender discrimination, some states in the United States (of America) (US) (e.g. California in 1985, New Jersey in 2004) have prohibited nightclubs and bars from offering ‘Ladies Night’—the practice of granting women reduced prices on cover charges or drinks (Wickham, 2004; Wright, 2004a). However, the more women that are present in a club, the more attractive it becomes for heterosexual men to enter the club as well. Thus, in equilibrium men pay more because they are receiving a higher value in return. Taking this point of view into consideration, the chosen price structure can be regarded as fair and also beneficial to men.

Consequently, to make an informed judgement about pricing strategies it is essential to ascertain whether one is dealing with a multi-sided market or not (Evans, 2009; Wright, 2004a). Suppose a monopolistic platform operator is employing a price structure where the first market side receives the service below marginal costs while the second side has to pay a premium. If a regulator solely considered the second side and was ignorant about the fact that the other side exists and is relevant, it could conclude that the platform was exploiting its position as a monopolist and charging excessive fees. However, in a multi-sided market a competitive equilibrium can have a comparable price structure so that it can be quite difficult to identify exploitation strategies (Wright, 2004b).

Concerning market power in multi-sided markets, regulators have raised an additional concern. In traditional markets with market power,

excessive prices lead to inefficiently low consumption. In contrast, in multi-sided markets regulators may suspect that the unequal price structure induces excessive consumption of the service. This argument is made in the context of payment cards¹. When consumers purchase a good or service with their payment card, they are generally not charged (or may even receive rewards, such as frequent flyer miles), while the merchant who accepts the card payment has to pay a service fee called the merchant usage fee to the card network.² This fee is automatically deducted from the amount the merchant receives from the card network for a sale. If consumers are lured into using their payment card by too a low price and merchants are not able to reject accepting payment cards (Vickers, 2005; Bolt & Tieman, 2008) then too many card transactions may occur in equilibrium at the expense of other methods of payment, such as cash or checks (Wright, 2010b; Rochet & Tirole, 2011).

To sum up, businesses in multi-sided markets have to balance their price structure with respect to at least two distinct customer groups who interact with one another. In doing so, they may attract the attention of regulators striving to determine the economical impact of their actions that can be quite different from what standard economic thinking would suggest. These two topics—pricing and regulation of multi-sided markets—are dealt with in this thesis. Before going into the details of the three articles in this thesis, however, a broader survey of the existing literature is provided.

1.2 SURVEY OF THE RELATED LITERATURE

This section offers an overview of the areas of research already conducted on multi-sided markets. It begins in section 1.2.1 with a classification of multi-sided markets. After this general introduction, there is a special focus on the payment card market as this is the best researched multi-sided market thus far and two articles in this thesis are concerned with payment cards.³ Section 1.2.2 offers a basic introduction into the payment card market followed by a discussion of the most widely used framework introduced by Rochet & Tirole (2002) in section 1.2.3. Section 1.2.4 takes on the discussion about the regulation of interchange fees and section 1.2.5 discusses the social costs of payment cards.

-
- 1 Payment cards is a generic term referring to debit cards (where the payment is directly deducted from a checking account), credit cards (where credit is provided by the card network and the actual payment is made at a later point in time) as well as charge cards (where payments can only be made up to the level that the card has been preloaded with by the holder). For the purpose of this thesis, the difference is mostly immaterial and the generic term is used.
 - 2 Other terms for merchant usage fee include merchant discount or merchant service charge.
 - 3 A more general overview of multi-sided markets is provided by Caillaud & Jullien (2003); Rochet & Tirole (2006b); Roson (2005).

1.2.1 *Classification of Multi-sided Markets*

Businesses in multi-sided markets are called platforms. They bring together other businesses and/or people (two distinct customer groups) and enable interactions among them. To begin, a general categorization of the different types of multi-sided markets is in order, which is best done according to their common functions. According to [Evans & Schmalensee \(2007a\)](#), multi-sided platforms are either matchmakers, audience builders, or cost sharers. Table 1.1 gives examples of these three types of platforms.

Matchmakers, such as eBay or NASDAQ, bring buyers and sellers together for all types of products. MySpace creates a meeting place for people with all sorts of personal interests. The common characteristic of these platforms is that they create value because they match people who need each other in one form or another and facilitate transactions between them. Additionally, the platforms can also settle disputes and create norms of behavior through a standardized set of rules designated by the platforms. They thus constitute an integral part of an economy.

Audience builders like Google or the British Broadcasting Corporation (BBC) offer content that appeals to potential customers of advertisers. Advertisers could not easily contact these potential customers on their own and thus buy their attention from these audience builders. It is a typical example where the presence of one side (the advertiser) does not increase the value of the platform to the other side (the audience). In other words, positive indirect network effects only flow in one direction, from the audience to advertisers. This business model has proved to be essential for online sites where consumers—the audience—have grown accustomed to receiving content and services for free.

Lastly and also important are the cost sharers. The Windows or Linux platforms provide a standardized programming environment that programmers can rely on to reach a substantial number of users of their programs. This common platform frees programmers of web browsers or office suites from worrying about how the internals of processing or graphics hardware function and allows them to concentrate on their specific products. In other words, they eliminate a duplication of effort.

This thesis is particularly concerned with payment cards and smart (electricity) meters. Both provide a common infrastructure and increase the efficiency of transactions and are thus cost sharers. Indeed, payment systems in general are a classic example of a cost-sharing multi-sided market. Independent of the variety of functions that multi-sided platforms perform, however, basic lessons are directly applicable to all varieties. Furthermore, the market for payment cards is

Matchmakers	Audience Builders	Cost Sharers
<i>facilitate transactions</i>	<i>assemble eyeballs</i>	<i>increase efficiency</i>
Shopping malls	Google	Payment cards
eBay	TiVo	Smart meters
NASDAQ	BBC	Windows
Manheim Auto Auction	Reed Elsevier	Linux
MySpace.com	The New York Times	SAP enterprise software

Table 1.1: Examples of multi-sided market types by function (adapted from [Evans & Schmalensee, 2007a](#), p. 7).

the most prominent and best researched multi-sided market.⁴ As a consequence, it is advisable to specifically look at the literature on this market. Lessons learned can then be transferred to the smart meter market.

1.2.2 The Basics of Payment Card Economics

Payment cards facilitate the payment process and reduce costs to merchants and consumers for handling monetary transactions. A transaction with a payment card network can involve up to five different actors: The consumer, the consumer's bank (issuer of the payment card), the card network, the merchant's bank (acquirer of payment transactions on the merchant's behalf), and the merchant. In a unitary network (such as Discover or American Express), there is only one institution performing the three functions of card network, issuer, and acquirer. In a multi-party-network (such as Visa or MasterCard) these are three separate institutions with hundreds of different banks acting as issuers and/or acquirers.

The setup of a payment card network can be seen in Figure 1.2, which shows the case of a unitary network in the top half of the illustration and a multi-party network in the lower half. The figure thus shows two distinct processes and both the consumer and the merchant in its center can only engage with one of these networks at the same time. A cursory explanation of the workings of a unitary network has already been offered in section 1.1. The consumer purchases a product from a merchant and pays price p to the payment network. The network then passes on the money to the merchant, but deducts a merchant usage fee a . In the case of a multi-party network, the consumer pays price p to the issuer. The issuer then passes on this amount to the acquirer, but deducts an interchange fee i . The acquirer books the money to the merchant's account minus the merchant usage

⁴ Excellent overviews of the literature are given by [Chakravorti \(2003\)](#); [Rochet & Tirole \(2006b\)](#); [Bolt & Chakravorti \(2008b\)](#); [Kahn & Roberds \(2009\)](#). [Evans & Schmalensee \(2005a\)](#) provide a comprehensive discussion of the whole industry.

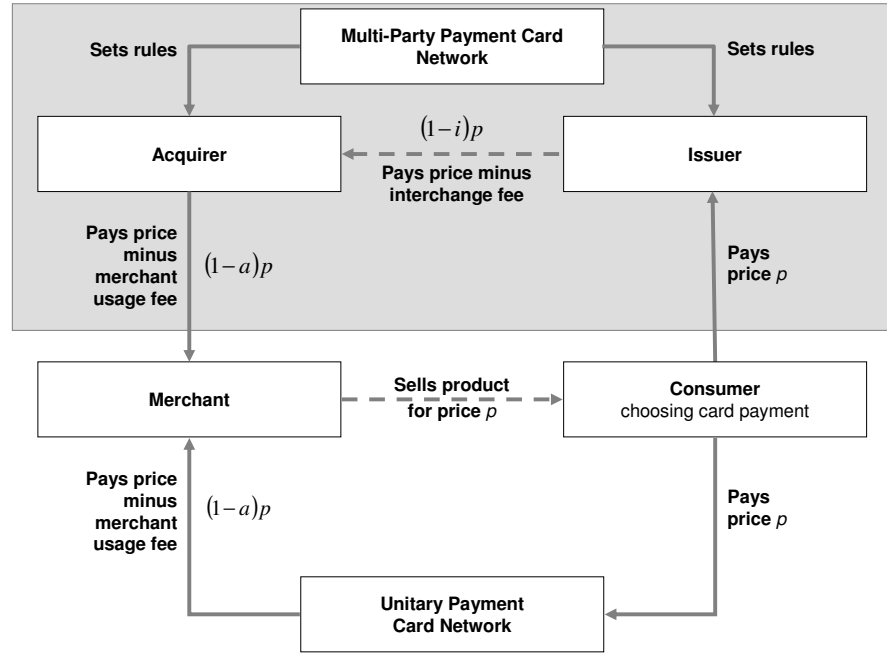


Figure 1.2: Workings of a unitary and a multi-party payment card network (Gans & King, 2003, p. 4).

fee a . Consequently, the merchant usage fee has to be at least as high as the interchange fee or $a \geq i$. Both the issuer and the acquirer have to pay a membership fee to the card network and agree to adhere to the rules that the specific network sets. Among others, these rules determine the level of the interchange fee.

The interchange fee especially has attracted great scrutiny ever since it became the focus of a lawsuit the bank NaBanco filed against Visa in the early 1980s (Chang & Evans, 2000; Evans & Schmalensee, 2007b). To facilitate transactions among its many member banks, Visa had set a unified interchange fee that all its issuer and acquirer banks had to adhere to when conducting transactions under the Visa brand. NaBanco argued that such a monopolistic price setting was anti-competitive, and individual banks should be allowed to negotiate terms for and among themselves.

Baxter (1983), who was the first to look at payment networks in a scientific article, provided some of the arguments against NaBanco's position. If every issuer were to negotiate its interchange fee with every acquirer, the number of necessary negotiations would simply be the product of issuers times acquirers, which would lead to prohibitive transaction costs. In addition, there was a significant free-rider problem. If one issuer were to unilaterally increase its fees, while others did not, the full revenue increase would accrue to this one issuer. The increased costs, on the other hand, would be spread among all acquirers who had to deal with this issuer. As a countervailing action, acquirers could refuse to do business with this issuer. That

scenario would mean that consumers and merchants could not be sure that a card from a specific issuer would be accepted at the store where they wanted to use it, thus significantly increasing uncertainty and reducing the true value of the card. Consequently, [Baxter \(1983\)](#) argued that card networks should be allowed to set common interchange fees and also impose an honor-all-cards rule that states that participating merchants must accept every card issued by a member of the network.⁵ In the end, the Eleventh Circuit ruled in favor of Visa, stressing the pro-competitive elements of a unified fee.

Nevertheless, the Court's decision did not end the discussion about interchange fees. [Carlton & Frankel \(1995\)](#) argue that the ruling was essentially flawed. Their argument is based on the neutrality of the price structure, which means that if acquirers were unwilling to pay interchange fees, they would be able to lower the merchant usage fee and the merchant in return could lower prices. Consumers could then pay less for the product, but they would have to pay a fee to the issuer for using the payment card. Overall, the allocation of fees would change, but total fees and revenues as well as the purchase amount would stay unaltered—thus producing neutrality of the price structure. Because the equilibrium would not change, issuers and acquirers should not have to face a unified interchange fee set by a monopolistic card network. To make matters worse, they argued that cash payers essentially were subsidizing card users since most merchants simply charged a common price for their products independent of the payment method. However, they were cautious in advising regulatory intervention into what was obviously a successfully operating business model without further evidence on the harmfulness of that business practice.

[Evans & Schmalensee \(1995, p. 891\)](#) provided the counter-notion, namely, that the “value of payment card services to consumers depends on merchant acceptance, and the value to merchants depends reciprocally on consumer usage.” This notion implies that the demand on one side of the market does not only depend directly on the price charged to that side, but also indirectly on the demand of the other side. This idea was an adaptation of the older notion of network effects introduced by [Katz & Shapiro \(1985\)](#). Traditional network effects are direct, e.g. the value of a telephone increases with the number of people who also have one. Katz and Shapiro also recognized that consumers indirectly benefit from buying popular hardware because more variety of software is then provided, thus stressing the value to the same market side, namely, the consumer. The importance of indirect network effects for a multi-sided market, however, derives from the value that at least one side of the market provides for the other.

⁵ However, in reviewing the history of non-cash payment systems, [Baxter \(1983\)](#) stressed that regulatory authorities had drawn a different conclusion in the case of check payments, essentially pushing for a zero interchange fee through the clearance system of the Federal Reserve.

This idea of indirect network effects plays an important role in most multi-sided market models. Platforms set prices in such a way as to get both sides on board rather than having a “fair” cost allocation, a practice that is widely approved of in the literature (Chakravorti, 2010). Apart from the fact that it is sometimes difficult to allocate costs to one side of the platform when having large fixed costs and low transaction-specific variable costs, costs are only one side of the coin. The other—and more important—side is the value the platform adds, which should be the main determinant of any efficient price structure. This insight that optimal prices may not reflect marginal costs is not limited to multi-sided market economics. In effect, it was recognized as early as with Baumol & Bradford (1970) who suggested that providing public utilities to each consumer at respective marginal costs might not be socially optimal. Faulhaber (1975) argued that pricing based on marginal costs does no more than ensure “that the production and sale of each commodity makes all consumers at least as well off as they would otherwise be.” Instead, by taking into account price elasticities of demand as well as cross-elasticities, one can make consumers better off. Multi-sided market economics thus inherited its focus on efficient price structures from the theory of multi-product pricing.

These two influences taken together—the theory of network effects and the theory of multi-product pricing—provided the groundwork for models on multi-sided markets (Rochet & Tirole, 2006b). Its breakthrough modeling framework and the immediate offspring it produced is discussed in the next section.

1.2.3 *The Rochet-Tirole Framework and Its Influence*

Many models that aim at comparing optimal interchange fee levels or try to understand the effects of different competitive setups are built on the model first introduced by Rochet & Tirole (2002). In this model, consumers and merchants obtain a convenience benefit from using a payment card, where benefits are derived from a distribution function. Merchants engage in Hotelling competition. Issuers demand a carduser fee (that can be negative so as to model rewards) from consumers, so that only those consumers use cards, for whom the individual benefit exceeds the fee. Acquirers are competitive and simply pass through the interchange fee as a merchant usage fee to merchants. They then set the interchange fee, using different objective functions to find equilibrium values for prices and fees. The first outcome is that credit card usage increases in the interchange fee to the point where merchants no longer accept cards.⁶ Secondly, the interchange fee that maximizes issuers’ profits is either socially optimal

⁶ A related point is made by Schmalensee (2002). If interchange fees are set collectively, output is maximized rather than reduced.

or above that level. Thirdly, merchants try to steal consumers from their competitors and thus internalize the cardholders' benefits.

Rochet & Tirole (2003) significantly altered this framework to show different competitive setups of two-sided platforms. They modeled a private monopoly, a Ramsey planner, as well as competition between for-profit and non-profit platforms. Most interestingly, they found that the price structure in all cases is skewed against one side (e.g. merchants) so as to get both sides on board. The main difference between a Ramsey planner and a private monopoly is that the former takes into account all positive externalities between the market sides. Further, for competition between platforms, the aspects of single- and multi-homing become relevant. A user single-homes, if she is only using one platform (e.g. only holds a Visa card), while she multi-homes, if she is using more than one platform (holds both a Visa and a MasterCard) and then can ultimately choose separately which platform to use for each transaction. A further result of the model is that the more users on one market side multi-home, the easier it is for the other side to ignore one platform and steer transactions towards the competing platform. The other market side then has to pay a lower platform price, since it is ultimately deciding, which platform will be used.

Wright (2004b) extended the original Rochet-Tirole framework by allowing for heterogeneous consumers and merchants, imperfectly competitive acquirers, and transaction-specific cardholder fees. With these alterations, the privately set interchange fee can be higher or lower than the socially optimal fee. The reason is that there are two (potentially countervailing) deviations from the social optimum. First, the network's profits can be transferred to the side of the platform where competition is least by increasing interchange fees, if these fees are directly passed on to merchants through higher merchant usage fees, but only transferred to consumers to a lesser degree. Second, there may be an asymmetry in the inframarginal effects. The marginal user does not take into account her value to all existing users on the other side of the platform.

Armstrong (2006) is concerned with different competitive environments between platforms in general. Therefore, he deviates from the Rochet & Tirole (2003) framework, employing certain technical variations regarding agents' utilities, platform fees, and costs. He finds that competition among platforms may skew prices even more towards one market side than if there were a monopoly platform, because exhibiting positive externalities is rewarded more extensively. If a monopoly platform loses such a beneficial user, the positive externality is lost altogether. In contrast, a duopolist platform may lose this user to the competition, where this user's positive externality may additionally lure other users away from the first platform. He further considers a case of competitive bottlenecks, where at one market side there is

a group of single-homers as well as a group of multi-homers. Platforms then increase prices to the multi-homers and use this revenue to compete for the patronage of single-homers.

These are important insights to be taken from this strand of literature. However, there is also one limitation, namely, that if merchants are heterogeneous, this aspect derives from unobserved variations. These unobserved variations are simply modeled through a random variable that represents a merchant's convenience benefit drawn from some distribution function. However, these models do not explain just how these differences emerge in the first place. The models in chapters 2 and 3, on the other hand, do model both a Bertrand and Cournot environment, respectively, where specific market characteristics can account for some of this variation.

1.2.4 *Regulation of Interchange Fee Levels*

A very intense discussion over the last few years has focused on the question of whether payment card fee levels should be regulated at all. For instance, in the US, debit card merchant usage fees are now restricted, leading some banks to start charging consumers for debit card transactions (Bernard & Protess, 2011). The motivation behind this legislation is to limit the exploitation of market power. As Schmalensee (2002) has noted, the premise is different than for most such cases, since companies with market power usually restrict output to increase prices and profits. An exploitative payment card network, on the other hand, would be able to increase prices (interchange fees), and profits as well as increase output by offering higher rewards to consumers and thus lure them into using their cards more often. Several recent articles have investigated the rationale for regulating interchange fees on this basis.

Wang (2010) models a mature card market with a fixed set of cardholders where the intensive margin of making existing consumers pay by card is most relevant. The multi-party card network, which acts like a unitary network because of competitive price taking acquirers and issuers, exerts vertical control over merchants. In his model, the card network increases the interchange fee when the technological costs of providing card services diminish. Reward payments as well as the transaction value also increase, but consumer welfare may not since products become more expensive, so that the card network is then able to extract the complete benefits of technological advances and economies of scale. The result is that the socially optimal interchange fee is lower than or equal to the monopoly interchange fee, but also higher than the minimum fee.

Wright (2010b) also shows that merchants are paying too much and consumers paying too little for payment services. His analysis mostly rests on the idea of strategic competition—or merchant internalization.

Merchants try to steal consumers from other merchants and internalize the consumer convenience benefit of using a payment card. They thus accept cards even if their own benefits are less than the merchant usage fee they have to pay because they hope to win the patronage of these consumers. [Chakravorti & To \(2007\)](#) use similar logic with the credit facility of credit cards in a two-stage game. In the first stage, merchants steal business from other merchants. However, because all merchants engage in the same game, they all end up in a prisoner's dilemma situation where no merchant gains any business on balance.

[Rochet & Wright \(2010\)](#) provide a rationale for regulating interchange fees based solely on the notion of consumer surplus. They specifically model the credit functionality of credit cards that can replace in-store credit supplied by some merchants and thus add value. Consumers can either use cash or credit card for ordinary purchases, and if nature allows, the credit card or the in-store credit for a second credit purchase. In their setup, the monopolistic payment network will set the interchange fee as high as the merchants can bear, so that the privately set interchange fee is always excessive and needs to be regulated to maximize consumer surplus. The degree of the reduction, however, depends on a tradeoff. For ordinary purchases, credit cards are more expensive than cash. These convenience consumers inflate costs and reduce welfare when using their credit cards excessively. For credit purchases, however, credit cards are less costly than in-store credit, creating the opposite effect when consumers switch to credit cards. If the first effect dominates (e.g. for medium-sized merchants) the necessary fee reduction would have to be larger than in a case where the second effect dominates (e.g. for small merchants). The latter—always appropriate—reduction would be a cap on the merchant's net avoided costs of not having to provide in-store credit.

The level of fee reduction proposed here is the same as in [Rochet & Tirole \(2011\)](#) and called the "tourist test threshold". Card fees should be low enough, so that a merchant does not want to refuse a card payment to a one-time customer holding sufficient cash. This argument is again based on the maximization of short-term consumer surplus. A key assumption is that merchants accept card payments if the merchant usage fee does not exceed the sum of the merchant and consumer benefits from card usage. In other words, merchants internalize the value that cards add to consumers because that practice makes the store more attractive to cardholders. Once the consumer has decided to buy, the merchant may have an incentive to steer the consumer toward cash payments, if the fees increase his operating costs. In this case, the fees fail the tourist test. In their benchmark model with constant issuer margins and homogeneous merchants the tourist test maximizes total user surplus, but the interchange fees are too low from a social welfare perspective, since the latter includes issuers' profits, which increase in interchange fees.

Overall, these models argue that there is some basis for interchange fee regulation. The reasons are distinct, but based on a special position of the card network. It is either able to extract all gains from technological advances and economies of scale, whereas a more balanced allocation could increase social welfare, or consumers are courted at the expense of merchants—by the card network itself or by merchants who engage in strategic competition. However, all these models are based on private prices of payment instruments observed in the market rather than real social costs. This so far missing perspective is provided by the articles discussed in the following section.

1.2.5 *Social Costs of Payment Instruments*

To discuss a social optimum, it is necessary to ask whether the private prices of payment instruments reflect true social costs. After all, no market participant is paying a direct fee for using cash, while it is obvious that providing coins and paper money does involve true social costs. According to [Humphrey \(2010\)](#) a country's payment system costs around 1% of Gross Domestic Product (GDP) annually; these are costs that are borne by the taxpayer in case of paper money. This fact is commonly disregarded in the literature, where the merchant usage fee and other card transaction costs are routinely compared to the private costs of handling cash. Social welfare comparisons are then conducted using these uneven terms.

One of the first studies to try to compare the costs of payment instruments comprehensively was conducted by [Humphrey & Berger \(1990\)](#). They found that overall, cash is the cheapest instrument, based on private as well as on social costs. However, apart from technological advances, one will notice that there are potentially large economies of scale in electronic payment processing. These have first been noted in other contexts. For instance, [Hancock et al. \(1999\)](#), based on an empirical investigation, argue that economies of scale are mainly responsible for price reductions in the Federal Reserve's Fedwire electronic funds transfer operation from 1979 to 1996. Furthermore, economies of scale are expected when integrating regional services and operations. Accordingly, reducing (transnational) payment costs is the main goal of a unified Single Euro Payments Area (SEPA). In this context, [Bolt & Humphrey \(2009\)](#) used the private payment data of six Dutch banks (ABN-AMRO Bank NV, ING Group, Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A. ([Rabobank](#)), Fortis N.V., Samenwerkende Nederlandse Spaarbanken ([SNS](#)), and Friesland Bank) for 1997-2005 to develop an estimation of scale economies. Their model suggests that doubling the payment volume could lead to reductions in average transaction costs of approximately 35%, however, while ignoring additional telecommunication expenses. For a cross-country panel of Euro countries, [Bolt & Humphrey \(2007\)](#)—using data on scale economies

from Norway, the Netherlands and Belgium and deriving predictions for the other countries through an estimated cost function—found the scale economies of debit card transactions to be around 0.11 for the Euro zone. Similarly, [Carbó-Valverde et al. \(2008\)](#) prepared an estimate for Spanish banks that doubling the volume of card processing would reduce costs by about one-third.

It has thus been argued that a switch from paper-based to electronic payments could lead to economies of scale and reduce overall transaction costs. [Humphrey et al. \(2001\)](#), based on semiannual panel survey data, estimated that a complete switch from a paper-based system to an electronic system using debit cards and electronic giro payments could save up to 0.6% of [GDP](#)⁷ in the Norwegian case. They assume that electronic payments cost only one-third to half as much as paper-based transactions and specified a model of payment choice based on direct price incentives at the point of sale. The Norwegian case is particularly interesting, as Norway has actively used cost-based price incentives to steer consumers towards use of electronic payment methods. [Garcia-Swartz et al. \(2006\)](#) obtained a similar finding. They conducted a marginal cost-benefit welfare analysis of payment choice to find that electronic transaction are significantly less costly for most transactions, while for small transactions, the differences are minimal. However, because payments cards charge merchants to a larger extent than prior payment methods do, merchants may end up paying a larger share of the burden. Lastly, [Guibourg & Segendorf \(2004\)](#) found for the Swedish case that private prices to consumers poorly reflect social costs and cash is substantially cross-subsidized even though electronic payments are less costly. They recommend steering consumers towards electronic payments.

Overall, payment cards have lower social costs than paper-based transactions do. However, when looking at private prices, studies have diagnosed excessive card usage and identified that merchants do shoulder a disproportionate share of the costs since card networks engage in price discrimination. They excise as high a fee as the particular merchants can withstand. As with usual price discrimination, prices are maximized. However, there is an additional aspect to this debate. Card companies have imposed a so called no-surcharge rule.⁸ It forbids merchants from surcharging based on the chosen payment method. In a world without transaction costs (where surcharging is costless), merchants could easily discriminate against more costly payment methods. Private prices would then be aligned with costs, so that

⁷ Note that this result is based on overall costs of the payment system of up to 3% of [GDP](#) annually. Ten years later, because two to three times less expensive electronic transactions are more widely used, the payment system in most countries costs around 1% of [GDP](#) annually ([Humphrey, 2010](#)).

⁸ A variant of the no-surcharge rule are cash discounts, which are sometimes allowed even if surcharging is not. A very detailed discussion of no-surcharge rules using private prices is given in [Schwartz & Vincent \(2006\)](#).

usage would become efficient from the point of view of the merchant. The interchange fee then becomes neutral because all costs can simply be passed on to the consumer (Carlton & Frankel, 1995). Some models thus predict that allowing surcharges would indeed improve overall welfare (Wright, 2003).

However, when merchants are not allowed to surcharge, they are not able to pass through the higher (private) costs of payment cards to cardholders. They employ an average price where cash consumers pay too much and cardholders pay too little. Cash consumers end up subsidizing cardholders. At least, this outcome is what conventional wisdom suggests and why regulators in some countries have forbidden no-surcharge rules.⁹ Taking into consideration that the social costs of payment cards are lower than those for cash, cardholders are subsidizing cash users through taxes. Bolt et al. (2010) have consequently argued that eliminating surcharges could efficiently lead to more card transactions. They observe that one in five merchants in the Netherlands surcharged in 2006—mostly small merchants and for small transactions below €10. This policy effectively deterred card usage, which would from a societal perspective be desirable. Imposing a no-surcharge rule could help, albeit at the expense of reducing the merchants' bargaining power, a circumstance that would have to be further observed.

1.3 FOCUS FOR THE STUDY AND MAIN RESULTS

In this context then, this thesis strives to offer new insights in two main areas. First, in the well-researched domain of payment cards chapters 2 and 3 investigate an aspect that has hitherto been scantily examined, namely, the fact that merchant usage fees differ substantially among merchant sectors. Additionally, if payment card networks are able to patronize certain sectors, which ones are they likely to pick? Second, chapter 4 identifies the smart (electricity) meter market as a multi-sided market and applies the insights found in the literature to better regulate a market-driven rollout of smart meters, the current objective in several countries and states, such as Germany.

Chapter 2 examines the determination of the merchant usage fee of a monopolistic unitary payment card network based on the characteristics of the downstream market. Merchants engage in Bertrand price competition that allows for an observation of heterogeneous products. My coauthor and I find that the payment card network extracts a part of the economic rent that merchants obtain. The higher this rent, the higher the corresponding merchant usage fee. The rent, and

⁹ The US Congress outlawed cash discounts in 1974, while prohibiting surcharges. Individual states may now have different regulations (for a detailed history see Chakravorti & Shah, 2001). According to Bolt et al. (2010, p. 1738), the Federal Reserve Bank of Australia has forbidden no-surcharge rules in 2003 and the European Payment Services Directive explicitly allows surcharging.

consequently the merchant usage fee, is increasing in the downstream market size, but decreasing in the price elasticity of consumer demand, as well as in the substitutability of products, and interestingly, in the fraction of consumers who prefer card payments. The intuition for this last result is that merchants increase prices if more consumers use card payments and overall sales thus go down. In reducing the merchant usage fee, the payment card network then tries to mitigate this effect.

Chapter 3 undertakes a similar analysis for Cournot quantity competition among merchants. The merchant usage fee is decreasing in terms of the price elasticity of demand and has an inverse V relationship with regard to the fraction of card users. At first, increasing the fraction of cardholders makes accepting cards more attractive for merchants because of the increased revenue they can obtain from actual sales. At some point, however, the higher costs of handling card transactions outweighs the benefit of increased revenue, and the optimal fee then decreases. Contrary to prior research, the number of merchants in a given sector is not found to influence the level of the merchant fee. Further, card companies can increase profits by influencing consumers to use their cards in sectors with a low price elasticity of demand where they can then tax a merchant's profits more heavily, which leads to a double marginalization.

Chapter 4 looks at smart (electricity) meters, regarded as a crucial element to increase energy efficiency by balancing energy supply and demand better. Nevertheless, most countries thus far have not seen a comprehensive smart meter rollout. A key economic obstacle to a market-driven rollout is the fragmentation of the benefits among multiple stakeholders, which disperses investment incentives. My coauthor and I investigate how best to overcome this investment barrier by analyzing three distinct smart meter market structures. A key parameter for the analysis is the recognition that the smart meter market is multi-sided, making it essential to consider its peculiar characteristics. Our qualitative analysis indicates that a combined smart meter and grid operator, with a regulatory setup that permits the socialization of smart meter investment costs among all electricity consumers, is the best suited approach to implement a market-driven smart meter rollout.

Part II

PAYMENT CARDS

MERCHANT FEE DETERMINATION IN UNITARY NETWORKS WITH PRICE COMPETITION AMONG MERCHANTS

This chapter is joint work with Markus Langlet.

2.1 INTRODUCTION

Over the past few decades the increasing use of payment cards has spawned the interest of researchers and governmental regulatory agencies.¹ Payment cards are an example of a two-sided market—a market that needs to attract two different groups of customers in order to function properly. As two-sided markets exhibit peculiar features contradicting standard microeconomic theory, they are an interesting research topic.

With regard to payment cards, the two distinct customers are merchants accepting card payments and consumers wishing to pay by card. Any card network can only operate if it attracts a sufficient amount of both customer groups. As a result, the two-sidedness of the market requires unique pricing strategies. Payment card networks do not only have to consider the price level (how much to charge in total) but also the price structure (the split of charges between the two market sides). It is a frequent feature of two-sided markets that one side is attracted by very low prices, while the other side is charged substantially.² In the case of payment cards, cardholders typically do not pay anything for card usage while merchants pay a per-transaction charge called the merchant usage fee. However, as the [European Commission Competition DG \(2006\)](#) has observed, as can be seen in [Figure 2.1](#), there are vast differences in the merchant usage fees across merchant sectors.

The figure shows the weighted average merchant usage fee per type of merchant sector across the [EU](#) in 2004. The results are part of an ongoing antitrust investigation against Visa and MasterCard. The figure shows that fees vary between 0.4% of turnover for charitable

¹ According to [Evans & Schmalensee \(2005b, p. 3\)](#), the ratio of card sales volume to total cash sales volume in the [US](#) has grown from about 3% in 1986 to 25% in 2000. [Bolt & Chakravorti \(2008b, p. 15\)](#), regarding the percentage of payment cards used for in-store purchases in the [US](#), refer to an increase from 43% in 1999 to 56% in 2005 (original source: [American Bankers Association and Dove Consulting \(2005\)](#)). More than 50 anti-trust cases have been filed since 2005 by merchants contesting interchange fees [Bradford & Hayashi \(2008, p. 1\)](#).

² Cf [Caillaud & Jullien \(2003\)](#) for further details on a strategy referred to as “divide and conquer”.

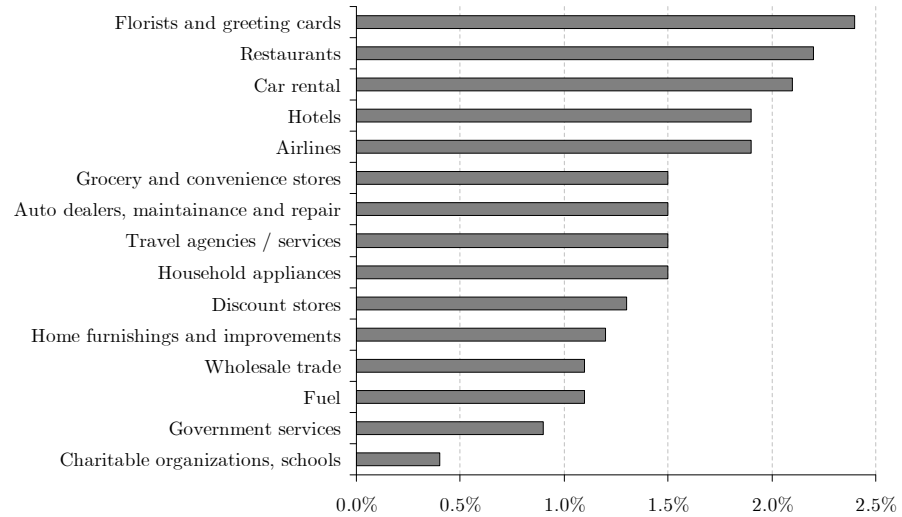


Figure 2.1: Weighted average merchant usage fee per type of merchant sector across EU, 2004 (European Commission Competition DG, 2006, p. 41, Graph 18).

organizations and schools to up to 2.4% for florists and sellers of greeting cards. Obviously, there is substantial variation. The lower bound might be a good indicator for the marginal costs of supplying the service and might only be offered on a pro-bono basis. However, it is not yet clearly understood why the variation between other sectors occurs. As an example, if it was simply a matter of the merchant size, why would airlines and car rental companies pay rather high fees?

In this paper we attempt to understand the reasons for these sectoral differences. We strive to enlighten the pricing decision of payment card networks dependent on the characteristics of a downstream market (the market the merchants face) where merchants have some market power. Our study can be seen as an extension of [Langlet \(2009\)](#) who investigates the merchant fee determination of a unitary payment card network with merchants under Cournot quantity competition. In contrast, we consider a unitary network and merchants under Bertrand price competition. Langlet finds that certain downstream market characteristics determine the merchant usage fee for the case of Cournot quantity competition among merchants selling a homogeneous product, e.g. the price elasticity of demand, the relative frequency of card usage and the competitive position of the merchants (i.e. monopoly power). We first illustrate a broader generality of Langlet's primary results to other competitive environments for the case of the price elasticity and the propensity of users to pay by card and gain useful new insights regarding the market size and product substitutability.

There are two factors that prevent Bertrand markets from yielding the strong theoretical result of competitive prices. The first are environments where firms face capacity constraints, following the contribution of [Kreps & Scheinkman \(1983\)](#). The second factor is a strategy of firms

to engage in product differentiation along the lines of [Singh & Vives \(1984\)](#)—given that homogeneous products are generally associated with less price dispersion ([Chiou & Pate, 2010](#)). We follow this second approach. Thus, the assumption of Bertrand price competition enables the analysis of heterogeneous products, which allows for an analysis of product substitutability as a downstream market determinant of the merchant usage fee. The intuition of product substitutability can be projected on a continuum which ranges from the products of different merchants being perfect substitutes on the one end of the continuum to the products being perfect complements on the other end. It hence seems essential to test price competition when talking about merchants in a range of sectors. However, we are aware that it is, in the end, an empirical question whether the Cournot or the Bertrand model are better suited for specific sectors.

2.2 UNDERSTANDING THE PAYMENT CARD MARKET

Payment card networks usually involve interactions of up to five players: a consumer, the consumer's bank (or the issuer), a merchant, the merchant's bank (or the acquirer), and the payment network providing the framework, which enables the transfer of payments among the agents (i.e., infrastructure, processes, transfer standards). When a consumer buys a product from a merchant and pays by card, the issuer charges the consumer's account and transfers the money to the acquirer who then credits the merchant's account. However, in order to execute these transactions, both the issuer and the acquirer bear costs for setting up and maintaining the needed infrastructure. The issuer typically does not charge the consumer for card usage, but covers the costs through an interchange fee deducted from the nominal amount it transfers to the acquirer. In turn, the acquirer does not credit the full nominal amount to the merchant's account, but instead deducts a so called merchant usage fee. The merchant usage fee has to be high enough to cover the interchange fee the issuer receives, as well as all other costs the acquirer incurs. All in all, through the merchant usage fee, the merchant is charged for the full costs of the card transaction and—to some extent—passes it on to consumers via higher prices.³

A significant part of the literature investigates payment card network pricing decisions. These are particularly interesting, because of the two-sidedness of the market at hand. [Evans \(2002\)](#) and [Evans \(2003\)](#) provide a detailed description of why two-sided markets lead to unexpected results. Firstly, two-sided markets exhibit positive network effects, meaning that the product or service becomes more valuable as more customers are using it. This makes the purchasing decisions

³ An extensive introduction into the payment card industry is given in [Evans & Schmalensee \(2005b\)](#).

of consumers interdependent. Consumers only want to use Visa if merchants accept it and vice versa. Secondly, the market platform has to sell two distinct products to each end of the market. In normal markets some firms may also sell multiple products, e.g. due to economies of scope. In contrast, companies in two-sided markets must sell both products if they want to remain in business at all. In business environments, this problem is often referred to as getting both sides on board.

Rochet & Tirole (2003) recognized that, because of these two features, firms have to choose a pricing structure, as well as a price level, in order to maximize profits. In other words, it is not enough to determine how much to charge in total, but which of the customer groups has to pay how much. Because each product benefits both customer groups, it does not make sense to apply standard microeconomic conditions, such as equalizing the marginal revenue to the marginal costs on each side. If lawmakers forced companies to price according to costs, they would firstly neglect the positive externalities each customer group exhibits on the other, and secondly, inflict upon them the problem that an allocation of costs to one side is often hardly possible; e.g.: Are costs for the payment infrastructure to execute a payment due to the consumer or the merchant? This leads to the conclusion that a regulation on the basis of costs does not work effectively in two-sided markets.

One part of the price structure decision is whether to charge fixed fees or to charge fees on a per-transaction basis. As Armstrong (2006) notes, platforms may internalize some of the positive cross-externalities by demanding per-transaction fees. In this way, customers from one group have to pay every time a member from the other group actually exhibits a positive externality. In doing so, a fraction of the interaction benefit is accounted for and market inefficiencies are attenuated to. For payment card networks, this means letting merchants pay every time they benefit from the positive externality they receive from each consumer paying with the card.

Another pricing decision is based on the tendency to multi-home. Customers are multi-homing when they use multiple competing platforms—e.g., merchants often accept both Visa and MasterCard and many consumers obtain several different payment cards. If it is the case that one customer group multi-homes, while the other one single-homes, the single-homers make the actual decision on which platform is being used. As a result, competing platforms have to make sure the single-homers choose them over the competition if they want to increase their revenues. Conversely, the multi-homing group draws less attention and ultimately receives fewer benefits. (Guthrie & Wright, 2007)

In the payment card industry, many merchants accepting one card typically also accept at least one other. This is facilitated by the fact that

e.g. Visa and MasterCard utilize the same technology, and thus, merchants only incur setup costs once when connecting to the network(s).⁴ On the other hand, a significant number of consumers single-home and, even if they do have more than one payment card, they make the final decision on which card to use. This explains the actual pattern in the price structure that can be observed in the market for payment cards, even though transaction costs seem to be lower on the acquirer side than on the issuer side. There is quite some competition for the patronage of consumers, and rather than having to pay for the service, consumers regularly receive benefits in the form of extended credit or frequent flyer miles. This also has to do with the fact, that we typically are confronted with a buyers' market. With this price structure of consumers receiving benefits rather than being charged a fee and with the consumer being the critical platform side, issuing appears far more profitable than acquiring.⁵ Merchants do not pay large fixed fees, but face significant merchant usage fees, which are a fraction of the value of each card transaction. In the remaining, the merchant usage fee is indicated by a .

One can conclude that in the payment card industry, it is quite well understood why merchants pay substantial per-transaction fees while consumers are enticed to use the cards and to a far lesser degree how fees may be set under different objectives. Accordingly, this study takes the explained and prevailing price structure as given and does not seek to explain it anew. We are thus not concerned with cross-group externalities that are a principle driver for the observed price structure. For the heterogeneity in fee levels among merchants, these externalities may not play such a crucial role. For simplicity, we are also not concerned with potential price discrimination of card issuers with regard to different consumer types (Amess et al., 2010).

The model of the payment card industry presented here is also related to the literature on vertical relations. We are investigating how an upstream monopoly is influenced by characteristics of a downstream duopoly. One question of interest in this literature has been to investigate the effects of a change in the downstream market (e.g. through a merger) on the upstream market (see e.g. Lommerud et al., 2005). One obvious difference is that in the payment card market merchants are not obliged to accept the input but can opt out of accepting the payment method leading to a price restriction. In the next section, we take a closer look at the downstream market—the merchant sector.

⁴ Often, a network offers credit as well as debit cards (the latter immediately charge a consumer's checking account and hence do not offer short-term credit in contrast to the former). With the so called honor-all-cards rule, some networks oblige merchants to accept the debit as well as the credit cards of the network; even so, the fees typically are different between the two of them. Rochet & Tirole (2008) found that the honor-all-cards rule has a socially balancing effect.

⁵ For details, refer to European Commission Competition DG (2006, pp. 62-77).

2.3 THE ROLE OF THE MERCHANT SECTOR

As mentioned earlier, the [EU](#) Commission Competition found that merchant usage fees vary significantly across merchant sectors (Figure 2.1). Additionally, the [United States Government Accountability Office \(2009\)](#) has identified four major factors that influence the price level of the payment card service:

1. The type of card: credit and debit cards, consumer, and commercial cards and rewards payment cards, all are associated with different fees
2. The merchant category: the merchant's line of business and the competitive environment
3. Merchant size or transaction volume: Merchants with a larger volume generally have lower rates
4. Processing mode: whether the cards are based on Personal Identification Number ([PIN](#)) or have magnetic swipe strips, or whether the transaction is over the internet translates to a different risk of fraud.

The second category could thus far only be insufficiently explained by the existing literature. As such, we want to add some insights to this point.

In this study we argue that the merchant usage fee depends on the characteristics of the downstream market. We employ a situation of Bertrand price competition in a duopoly of merchants where each merchant sells one product. The products from merchants 1 and 2 may be either complements or substitutes to reflect a continuum of different competitive situations. The downstream market may also vary in market size and the price sensitivity of consumers.

We are interested in the effects of the characteristics of the downstream market on the merchant usage fee and thus try to model other market features as simply as possible. As already noted, we take as given the price structure that payment card networks choose in reality and do not model any other charges apart from the merchant usage fee. Furthermore, we avoid the discussion about interchange fees by looking at a monopolistic unitary payment network. Unitary networks are such where the acquirer, the issuer, and the payment network are one entity so that we only have to worry about covering the costs of the whole transaction service.⁶ The workings of a unitary payment card network can be seen in Figure 2.2.

While such unitary networks exist—most notably American Express and Discover Card—we want to argue that our results extend, as [Schwartz & Vincent \(2006\)](#) have noted, to the case of multi-party

⁶ See [Schwartz & Vincent \(2006\)](#) for a similar treatment.

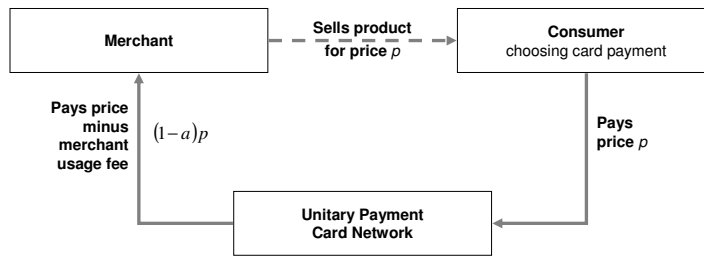


Figure 2.2: Organigram of a payment card network. Confer Gans & King (2003, p. 4).

networks under two assumptions: a) a competitive acquiring market that passes through interchange fees (as assumed for example in Rochet & Tirole, 2002), and b) identical issuing banks that collude in prices and thus maximize the sum of the banks profits. Furthermore, in multi-party networks, acquirers face incentive structures similar to the unitary network of our model because the acquirer simply passes on a fixed fraction of the merchant usage fee to the issuer through the interchange fee. As a result, the acquirer's share is simply reduced by a proportional amount.

So far, most of the governmental regulatory activity has been concerned with multi-party networks. While it is true that Visa and MasterCard are the largest networks and leading banks in their system are among the biggest players in the banking industry, they still face competition from other banks within their systems that have to play by the same rules. Even if the collective setting of interchange fees limits some form of competition, the problem is aggravated in the context of unitary networks. Not only do unitary networks not have to worry about interchange fees and can more easily cross-subsidize between the platform sides, neither do they face competition within their system. As a matter of fact, merchant usage fees of American Express have been higher than those from Visa and MasterCard since the beginning of these multi-party payment card networks. This has been attributed to the role of American Express as a first-mover and the fact that American Express is historically very familiar with the travelling business, which is one of the prime segments of the payment card industry.⁷ Again, the downstream market may play a crucial role in this context, which should thus be thoroughly understood.

In the next section, we present our model starting with the general outset in section 2.4. We then look at the characteristics of the downstream market that are influencing the merchant usage fee on the consumer side in section 2.4.1 and the equilibrium and merchant behavior in section 2.4.2. In section 2.4.3 we analyze how the monopolistic unitary payment network anticipates the results in the

⁷ This might be especially true for business travelers.

downstream market and adjusts the merchant usage fee accordingly. Section 2.7 concludes.

2.4 THE MODEL

Our model economy is populated by two identical merchants in the same sector who have some monopoly power as they engage in Bertrand price competition. In the case of Bertrand competition, two players are typically sufficient to generate competitive benefits. Each of the merchants sells one product to a continuum of consumers. Payments are made by using either cash or a payment card⁸. A fixed proportion of consumers will only purchase when allowed to use a payment card, while all other consumers prefer to pay cash.⁹ We do not take into account any strategic considerations on either side of accepting or using payment cards. Let there be one monopolistic unitary payment card provider that charges a merchant usage fee while letting consumers use the card without any charge. Therefore, we take the price structure adopted by the payment network as given and focus on the determinants of the merchant usage fee.¹⁰

Furthermore, consider the timing of the game as follows:

1. The payment card network sets a profit maximizing merchant usage fee.
2. Merchants decide whether to accept card payments or not.
3. Merchants maximize profits by setting a price for their product and anticipating the demand behavior of consumers.
4. Consumers make their purchasing decision.

The game is solved by backward induction.

2.4.1 Consumers

In the last stage, we model consumer behavior based on a standard Bertrand price competition model analogous to Singh & Vives (1984)

⁸ Our model applies to all kinds of payment cards. That's why we stick to the general term. However, the casual reader might find it easiest to think about the model with regards to credit cards.

⁹ The assumption that consumers indeed have a strict preference for card payments and will not purchase at all if a merchant rejects it may appear to be very strong. We do not think it is. For a detailed discussion, see Section 2.6.

¹⁰ Our chosen price structure resembles the characteristics of payment cards in many countries where consumers usually only have to pay a small annual fixed fee and frequently enjoy additional benefits of card usage. E.g., according to the semi-annual Federal Reserve Survey most US payment cards do not charge membership fees and none charge on a per-transaction basis for domestic purchases (Board of Governors of the Federal Reserve System, 2010).

and we also mainly stick to the nomenclature of this section. Accordingly, we have the following demand functions

$$q_1 = A_1 - B_1 p_1 + \tau p_2 \quad (2.1)$$

$$q_2 = A_2 - B_2 p_2 + \tau p_1 \quad (2.2)$$

Hence, A_i is a measure of the market size, whereas B_i represents the sensitivity of the demand to own-price changes of merchant $i = 1, 2$, respectively, and τ reflects the sensitivity to changes in the price of a comparable product from a different merchant. Furthermore, we assume without loss of generality that $B \geq \tau$.¹¹

We also derive the price elasticity of demand ϵ .¹²

$$\epsilon_{q_1, p_1} = \left| -\frac{p_1 B_1}{A - B_1 p_1 + \tau p_2} \right| \quad (2.3)$$

It is easily verified that our model is consistent with standard assumptions about demand behavior as indicated by Lemma 2.1.

Lemma 2.1. *The stronger consumers react to the price changes of the first (second) merchant the higher (lower) the price elasticity of demand for the first product, since:*

$$\frac{\partial \epsilon}{\partial B} > 0 \quad (2.4)$$

$$\frac{\partial \epsilon}{\partial \tau} < 0 \quad (2.5)$$

Please note that proofs are delegated to the Appendix. The first part (2.4) is straightforward because own-price sensitivity B and own-price elasticity are virtually synonymous. As the own-price sensitivity increases, demand will react stronger and decline sharper after a price raise. The second part (2.5) has a sensitivity effect as well as a quantity effect. With an increasing τ , consumers react more strongly to the prices of the other merchant—they become more sensitive to the competition. In addition, the first merchant sells more of his products at a given price level. In other words, the own-price elasticity of consumer demand is decreasing as they react less severely to own-price changes of this merchant, relative to the reaction to the prices of the other merchant.

2.4.2 Merchants

We take as given the matching process between buyers and sellers and assume that merchants maximize their profits by setting prices.

¹¹ In other words, the price that a merchant charges has at least as much influence on the buying decision as the price of the other merchant.

¹² Given our assumptions about B and τ , the price elasticity is negative. Demand always decreases when prices are raised. However, we define it in the standard way as being the absolute value.

Because of symmetry, it suffices without loss of generality to look at one merchant only. The resulting profit function provides

$$\pi(p_1, p_2) = (1 - \gamma a) p_1 q_1(p_1, p_2) - c q_1(p_1, p_2) \quad (2.6)$$

where γ denotes the fixed proportion of consumers who will only purchase the product if they can effect a card payment. All other consumers will use a different payment method we refer to as cash. If consumers pay by card the merchant has to pay the merchant usage fee a as a percentage of the transaction volume of each purchase to the payment network. Accordingly, we have $0 < a < 1$, as well as $0 < \gamma < 1$. Assume that merchants incur constant variable costs c with the sale of every product but do not have any fixed costs. The function thus defines profits as revenues minus payment card transaction costs and procurement costs.

Given this profit function, merchants face higher costs when consumers use payment cards.¹³ For parsimony and without loss of generality, we only include the merchant usage fee in our model and assume all other costs to be negligible.¹⁴ In addition, consumers have to pay the same price no matter whether they pay in cash or by card.¹⁵

We now assume, again for parsimony, that merchants are not only symmetrical, but identical, such that we have $A_1 = A_2$ and $B_1 = B_2$. Substituting (2.1) into (2.6) yields the profits the unitary network will strive to maximize.

$$\max_{p_1} (A - B p_1 + \tau p_2) p_1 (1 - \gamma a) - c (A - B p_1 + \tau p_2) \quad (2.7)$$

Because of merchant symmetry, they will set the same price in equilibrium $p^* = p_1 = p_2$. In addition, at this stage we take as given that both merchants accept card payments. Taking the First Order

¹³ Similarly, some studies suggest that the costs involved in accepting and managing cash payments are smaller than the costs of accepting payment cards [Chakravorti \(2003\)](#); [Wang \(2010\)](#).

¹⁴ An alternative interpretation would be to look at a as the differential between the merchant usage fee and the cost of accepting and managing cash. This, however, would make the following interpretation of a slightly more complicated without adding much value to the analysis.

¹⁵ Some networks try to contractually oblige merchants not to surcharge for card payments (the so-called no surcharge rule). This has raised interest among competition authorities. [Bolt & Chakravorti \(2008a\)](#) claim that such a rule makes consumers and merchants worse off while banks benefit. However, there is strong empirical evidence that most merchants do not surcharge even in the absence of a no surcharge rule (e.g., refer to [Bolt et al. \(2010\)](#) and [ITM Research \(2000\)](#) for the Netherlands as well as [ITM Research \(2000\)](#) for Sweden) aside from some peculiar business settings such as online sales, where surcharging of card payments is often found. Even so, surcharging is a rather uncommon practice. As [Chakravorti & To \(2007\)](#) have noticed, when merchants are willing to inflict these higher prices on all consumers rather than surcharging for card payments, this strengthens any results in which they do accept payment cards. Because if they could surcharge they would then certainly be willing to accept card payments.

Condition (f.o.c.), then setting prices equal and solving for p^* leads to Lemma 2.2.

Lemma 2.2. *The equilibrium in the downstream market is characterized by*

$$p^* = \frac{1}{2B - \tau} \left(A + \frac{Bc}{1 - \gamma a} \right) \quad (2.8)$$

$$q^* = \frac{B}{2B - \tau} \left(A - \frac{(B - \tau)c}{1 - \gamma a} \right) \quad (2.9)$$

$$Q^* = 2q^* = \frac{2B}{2B - \tau} \left(A - \frac{(B - \tau)c}{1 - \gamma a} \right) \quad (2.10)$$

The first thing to notice is that we have $\frac{\partial p^*}{\partial \gamma} > 0$ and $\frac{\partial q^*}{\partial \gamma} < 0$. All consumers, card paying as well as cash paying, bear the additional costs due to card payments. Hence, with a constant merchant usage fee the more consumers use their payment cards and thus inhibit these transaction costs on merchants, the higher the equilibrium price will be and the lower the equilibrium quantity.

At the second stage of the game, merchants decide whether to accept card payments or not. There is a certain proportion of consumers who will only purchase the product if the merchant accepts card payments, thus, the necessary and sufficient condition for card acceptance is that merchants make non-negative profits with respect to these consumers. We denote the threshold merchant usage fee that yields this result as \bar{a} . Any fee above this level will make merchants reject card payments, while they would accept it for any fee below the threshold.¹⁶

In order to calculate the maximum acceptable discount \bar{a} we have to compare the profits a merchant makes when accepting card payments to those when he does not accept it. As we can see from (2.8) and (2.9) the equilibrium price and quantity will differ in these cases. We assume that the payment network sells no other products to merchants than the card service. Therefore, there is neither a subsidy of other banking services nor any other motivation than payment services for merchants to make business with the network. Hence, merchants decide whether to accept the payment service solely based on the level of the merchant fee. The profits are thus given by

$$\pi_{nc}(p_1, p_2) = (1 - \gamma) q_{1,nc}^* (p_{1,nc}^* - c) \quad (2.11)$$

¹⁶ With regard to this it has to be stated that we are ignoring that card acceptance might be a competitive instrument and thus overstating merchant resistance. Guthrie & Wright (2007) provide a rationale for \bar{a} since they find that with homogenous merchants regarding the benefits and costs of the card services competing payment card schemes will strive for achieving the optimum merchant usage fee provided merchants still accept cards. (Chakravorti, 2003) This will be true for pretty much all situations where the merchant usage fee is lower than the equilibrium merchant usage fee a^* which will be derived in the remaining.

$$\pi_c(p_1, p_2) = q_{1,c}^* (p_{1,c}^* - a\gamma p_{1,c}^* - c) \quad (2.12)$$

where the indices c and nc indicate card acceptance and non-acceptance of payment cards, respectively.

The maximum merchant usage fee \bar{a} is then implicitly given by

$$\pi_c = q_{1,c}^* (p_{1,c}^* - \bar{a}\gamma p_{1,c}^* - c) = (1 - \gamma) q_{1,nc}^* (p_{1,nc}^* - c) = \pi_{nc} \quad (2.13)$$

and the merchants will not accept any fee that is above this threshold, so we have $a \leq \bar{a}$.

2.4.3 The Payment Card Network

Going back to the first stage of the game, the payment card network anticipates the merchant behavior p^* as well as the resulting market equilibrium $Q^* = 2q^*$. We assume that the network does not incur any variable costs, but only fixed costs C . The rationale is that large investments are necessary to introduce and operate a payment network, while the actual per-transaction costs are minimal and can be ignored. The network chooses the actual merchant usage fee and makes a take-it-or-leave-it offer to the merchants. In other words, merchants do not have any bargaining power.¹⁷ However, merchants do have a maximum willingness-to-pay that the network anticipates and sets the usage fee accordingly, so that we have $a \leq \bar{a}$.

As network profits amount to fee revenues minus fixed costs, the profit function can be written as

$$\max_a \Pi(a) = p^*(a) Q^*(a) \gamma a - C \quad (2.14)$$

or equivalently, after inserting the equilibrium values

$$\max_a \Pi(a) = \left(\sigma + \frac{\phi}{1 - \gamma a} - \frac{\xi}{(1 - \gamma a)^2} \right) \gamma a - C \quad (2.15)$$

where $\sigma = \frac{2A^2B}{(2B-\tau)^2}$, $\phi = \frac{2AB\tau c}{(2B-\tau)^2}$, and $\xi = \frac{2B^2c^2(B-\tau)}{(2B-\tau)^2}$.

The corresponding first order condition gives the optimal merchant usage fee.

Lemma 2.3. *The optimal merchant usage fee level a^* is a function of (A, B, τ, γ) . It is implicitly defined by*

$$\left[\sigma + \frac{\phi}{1 - \gamma a^*} - \frac{\xi}{(1 - \gamma a^*)^2} \right] \gamma + \left[\frac{\gamma \phi}{(1 - \gamma a^*)^2} - \frac{2\gamma \xi}{(1 - \gamma a^*)^3} \right] \gamma a^* \stackrel{!}{=} 0 \quad (2.16)$$

¹⁷ For a detailed discussion of this assumption, see Section 2.6.

The optimal merchant usage fee is implicitly defined by the [f.o.c.](#) of the profit function. The main idea behind this study is that the parameters (A, B, τ, γ) are the driving forces behind the determination of the merchant usage fee. As the characteristics in the downstream market change the payment network should adjust their pricing strategy accordingly.

Proposition 2.1. *The optimal merchant usage fee is increasing in the market size and the impact of other merchant's prices, but decreasing in the own-price sensitivity of demand, as well as in the fraction of consumers paying by card.*

$$\frac{\partial a^*}{\partial A} > 0 \quad (2.17)$$

$$\frac{\partial a^*}{\partial B} < 0 \quad (2.18)$$

$$\frac{\partial a^*}{\partial \tau} > 0 \quad (2.19)$$

$$\frac{\partial a^*}{\partial \gamma} < 0 \quad (2.20)$$

Proof. See Appendix. □

The main interpretation of these results is that with a more competitive market environment in the downstream market, the payment service networks have to lower the merchant usage fee. Essentially, the payment card network obtains a share of the economic rents. If competition in the downstream market is higher and profits of merchants are lower, there is a smaller total fee revenue to be shared. Consequently, the price the network can charge decreases. This intuition can be broken down to the individual formulas.

The result in (2.17) states that the merchant usage fee increases in the size A of the market the merchants penetrate. If merchants serve a larger market in an otherwise unchanged competitive environment, they obtain larger profits. But remember that the payment network is in a strong bargaining position and can make take-it-or-leave-it offers. It will consequently want to earn a major share of these profits and will charge a higher price for its services. The caveat is that with increasing size merchants are likely to have a larger bargaining power. Since we do not look at bargaining power issues in our model, we do not find this supposedly countervailing effect. However, we still think that the result is applicable to a wide range of markets, where merchant bargaining power is not a major determining factor, if at all.

Then, there is the price sensitivity of consumer demand in (2.18) and (2.19). For B , this refers to the own price the merchant sets while τ measures a sensitivity to the price of the other merchant. Regarding the former, when the own-price sensitivity of demand is higher, less of the fee can be passed on. As a result, the optimal fee level decreases. The opposite logic applies for τ . If τ increases, higher prices of the other

merchant will have a stronger impact on the first merchant's sales. This also translates into a higher sales quantity of the first merchant at given prices. It therefore increases this merchant's minimum sales quantity, no matter his own price, and provides each merchant with more monopoly power. The overall result is that a higher merchant usage fee can be passed on.

The last statement (2.20) claims that the optimal merchant usage fee is decreasing in the fraction of consumers who prefer to pay by card. We know that without surcharging, the merchant usage fee is passed on to all consumers—whether they are paying in cash or with a card. We have already established that the equilibrium market price is increasing in γ , as well as in a ($\frac{\partial p^*}{\partial \gamma} > 0$, $\frac{\partial p^*}{\partial a} > 0$), while the equilibrium quantity is decreasing in γ as well as in a ($\frac{\partial q^*}{\partial \gamma} < 0$, $\frac{\partial q^*}{\partial a} < 0$). The rationale is that merchants are increasing product pricing when facing the higher costs of more consumers paying by card. As a result, the equilibrium quantity will go down. However, the payment card network anticipates this behavior. As can be seen in (2.14) its profits are given by the product $p^* q^* a^* \gamma$. In addition, if γ increases, p^* is increased by the merchant and q^* decreases in the market. We find that the payment card network's reaction is to decrease a .

Another way to look at the optimal relationship of proposition 2.1 is through the price elasticity of demand. Remember that the elasticity is determined by the other variables treated above. It is thus a function of all three variables ($\epsilon(A, B, \tau)$). We obtain

Proposition 2.2. *The merchant usage fee is decreasing in the price elasticity of demand.*

$$\frac{\partial a^*}{\partial \epsilon} < 0 \quad (2.21)$$

From Lemma 2.1 we know that the elasticity is decreasing in τ ($\frac{\partial \epsilon}{\partial \tau} < 0$). As the optimal merchant usage fee is increasing in τ , it has to be decreasing in the elasticity $\frac{\partial a^*}{\partial \epsilon} < 0$. The interpretation of this result is analogous to $\frac{\partial a^*}{\partial B}$. The own-price sensitivity of consumers is equivalent to the price elasticity. This relation is illustrated in Figure 2.3.

2.5 ALTERNATIVE FORMULATION WITH INVERSE DEMANDS

Regarding the foregoing demand functions (2.1) and (2.2), Singh & Vives (1984) give an alternative way of presenting these results starting from the inverse demand functions

$$p_1 = \alpha_1 - \beta_1 q_1 - \theta q_2 \quad (2.22)$$

$$p_2 = \alpha_2 - \beta_2 q_2 - \theta q_1 \quad (2.23)$$

Using these, our exogenous variables from (2.1) and (2.2) are dependent on α , β , and θ , with $A_i = \frac{\alpha_i \beta_j - \alpha_j \theta}{\delta}$, $B_i = \frac{\beta_i}{\delta}$, $\tau = \frac{\theta}{\delta}$, and

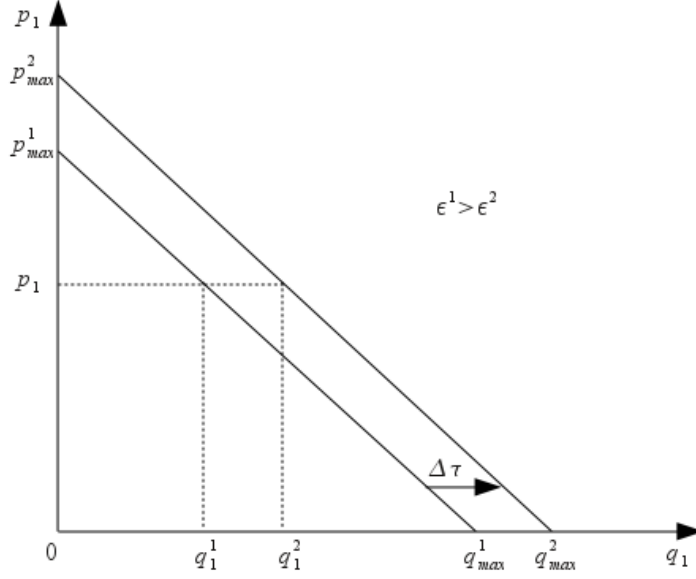


Figure 2.3: Effects of an increase in τ . At a given price, sales quantity increases while price elasticity decreases.

$\delta = \beta_1\beta_2 - \theta^2$ with $i, j = 1, 2$ and $i \neq j$. Furthermore, we assume without loss of generality and analogous to our first case that $\beta_i \geq \theta$. In other words, the price that a merchant charges has at least as much influence on the buying decision as the price of the other merchant. The demand function allows for products to take any relation in between being full substitutes or full complements based on the parameter θ . For $\theta = 0$ the two products are completely independent and each merchant is a monopolist whereas for $\theta > 0$ the products are substitutes (for $\theta < 0$ complements). Products become perfect substitutes when $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2 = \theta$. Consequently, we obtain θ as an interesting variable for substitutability of the two products while the other variables are not as easily interpretable.

The goods are substitutes, when $\theta > 0$, independent (in other words the merchants are monopolists) when $\theta = 0$, or complements when $\theta < 0$. Since product substitutability is derived from the inverse demand function, θ is a function of A , B , and τ . By comparative statics regarding the equilibrium merchant usage fee and product substitutability, we derive the following result.

Proposition 2.3. *The optimal merchant usage fee is decreasing in the product substitutability.*

$$\frac{\partial a^*}{\partial \theta} < 0 \quad (2.24)$$

Proof. See Appendix. □

The interpretation that the optimal merchant usage fee is decreasing in the substitutability of the two products is consistent with our result

from Proposition 2.2 as a higher product substitutability increases the price elasticity of demand.

2.6 COMPREHENSIVENESS OF THE RESULTS

As this model extends the approach of Langlet (2009) to Bertrand price competition, we can confidently state that the merchant usage fee depends on downstream market characteristics for a variety of different market structures. However, we have made some crucial assumptions in this paper that deserve a closer examination.

As stated before, we have assumed that consumers have a strict preference for card payments and will not purchase at all if a merchant rejects payment cards. An alternative modeling setup could include both consumers with a weak preference (who will pay cash if that's the only accepted method) and with a strong preference (who will refrain from buying altogether). The result would be a lower threshold for the maximum acceptable merchant usage fee \bar{a} . However, once a merchant decides to accept card payments and there are a proportion of consumers paying by card all the other interpretations that we derive later in the model would still hold. We thus have chosen to stick with the simpler approach. As long as the maximum threshold is not crossed, the distinction between a weak and a strong preference for card payments is immaterial and does not make a difference. Furthermore, there is some support for a strict preference through the fact that merchants experience increased sales after accepting payment cards (Chakravorti, 2003). Because payment card transactions are more costly than cash transactions, there might not be any incentive for merchants to accept payment cards if sales did not increase.

Another assumption that we make is that merchants do not have any bargaining power when negotiating merchant usage fees, but have to accept a take-it-or-leave-it offer. We acknowledge that large merchants do have some leverage to reduce fees. The European Commission Competition DG (2006) does recognize size as one factor of bargaining power and found that the fee is sometimes only negotiated with larger merchants. However, even large merchants are relatively small compared to the market size of the large payment card networks with transaction volumes of \$465 billion of American Express and \$1,370 billion of Visa and MasterCard in the US in 2008 (Federal Reserve Bank of Kansas City, 2009). Consequently, for the US the United States Government Accountability Office (2009) found that "representatives from some of the large merchants with whom we spoke [...] reported that their inability to refuse popular cards and network rules (which prevent charging more for credit card than for cash payments or rejecting higher-cost cards) limited their ability to negotiate payment costs." In addition, in multi-party networks the largest chunk of the total merchant fee is the interchange fee set collectively by the card

network. Acquirers negotiating with large merchants hence only have a limited scope for negotiations. We thus think it is a supportable assumption to model the merchant usage fee as a take-it-or-leave-it offer of the card network to the merchants. Again, as in the current paper we are not interested in the complicated interrelationships of acquirers, issuers, and the card network service we treat these as one entity. For multi-party networks the incentives for the acquirer are the same as in the unitary network case. While the interchange fee is fixed by the network, the acquirer sets the additional fee optimally, resulting in the final merchant usage fee. A more complicated model including a multi-party network should hence yield similar results. Nevertheless, our setup is naturally the best fit when looking at unitary payment networks.

The bargaining power of merchants can also be thought of as a function of the merchant's size. Even though size does not seem to be the overarching explanatory factor for the merchant usage fee, it does seem to be an influential one. This influence might also be a worthwhile object of a different article. The payment card network's objective function in our framework is optimized by setting the merchant fee. If this fee is reduced because a large merchant has more bargaining power, the network may devote its efforts to optimizing the opposite market side: increasing the number of card paying consumers that will then increase fee revenues and, over time, reduce the merchant's bargaining power. Such a framework may explain developments in the payment card industry over time.

Related aspects have been investigated in the literature on vertical relations (see [Chemla, 2003](#)). If merchants are assumed to have bargaining power, downstream market competition introduces a further tradeoff. Less merchant competition increases merchant profits that can be extracted by the payment card network. However, in a Nash bargaining framework, it would also lead to a higher bargaining power of merchants that reduces the ability of the payment network to extract rents. This strategic tradeoff could be an object of further investigation.

Another reason for a higher bargaining power of merchants may be competition among different payment card networks. Because of such competition, a single network may be unable to make take-it-or-leave-it offers and will have to engage in direct negotiations with merchants. The actual market reality will be influenced by at least two factors: first, the degree of multi-homing of card users and, second, the competitive environment of the payment card network. If consumers single-home and only have one payment card available which they want to use for their purchases, card competition only has a limited effect on the merchant's ability to refuse single cards. Regarding the competitive environment for the payment card network another model could deviate from a monopolistic unitary payment network. In reality,

we do see competition among different networks and in multi-party networks among different acquirers of one network.

2.7 CONCLUSION

We have shown that the merchant usage fee depends on factors of the downstream market. We find the optimal merchant usage fee is increasing in the downstream market size and decreasing in the products substitutability, as well as the fraction of consumers strictly preferring card payment. The rationale is that the payment card network is extracting part of the rent from the merchants. As a result, the merchant usage fee is an increasing function of the merchant's rent.

We can compare our findings with the actual average merchant usage fees the [European Commission Competition DG \(2006\)](#) has found and is displayed in Figure 2.1. For example, fuel is a fairly homogeneous product. Hence, drivers are rather price sensitive when comparing different gas stations. In contrast, restaurants offer rather in-homogeneous products, spreading from fast food to exclusive gourmet cuisine. Hence, the price sensitivity of consumers is likely to be weaker among different kinds of restaurants. Consequently, the observation that restaurants, on average, pay a merchant usage fee of 2.2% and gas stations pay 1.1% of the transaction value is in line with our findings above. It would be a very interesting extension to test these hypotheses in a rigid empirical framework. However, we leave this point for future work.

Another way to look at the competition between the merchants would be in terms of a Hotelling setup, where the two merchants are located at each end of a continuum and consumers are uniformly distributed along the spectrum. Every consumer has to pay the price of the product and transport costs in order to overcome the distance and make a purchase at each of the merchants. An extension of this model could argue along these lines and investigate size and distribution effects. Another complication arises if we look at a market with more than two merchants. When there are more than two merchants, the monopoly power of a single merchant decreases and thus, each merchant's profits decrease, as the market resembles the case of perfect competition more closely. Consequently, the merchant usage fee should be lower in such a setup.

Our model also provides a rationale for lower merchant usage fees when more consumers are using payment cards. The effects of an increased number of consumers paying by card are balanced by a decreased merchant usage fee. [Chakravorti & To \(2007\)](#) find the opposite result. In their model, the more people use credit cards, the higher the fee the payment network can charge. This is because in their model, the driving force is the easier access to credit that credit cards enable, which then gives liquidity constrained consumers the

ability to consume in an earlier period. Thus, merchants increase their sales in the present at the expense of other merchants' sales in the future. However, if all merchants accept credit cards, the result is a prisoner's dilemma, where all merchants face the higher costs of credit cards, while no actual sales increase takes place. The [United States Government Accountability Office \(2009\)](#) reports that merchants now claim that the increased sales through card acceptance cannot make up for the rising fees they have to pay. As card acceptance in the [US](#) is very widespread, such a prisoner's dilemma situation may actually have occurred.

In contrast, we do not include a liquidity constraint and a multiple period perspective in our model. Alternatively, another explanation seems plausible. We have assumed that the payment networks make a take-it-or-leave-it offer to the merchants. Nevertheless, it is reasonable to assume that merchants do have some bargaining power over the fee level. The more consumers insist on card payments and, consequently, the higher the positive externality that payment card users exhibit on merchants, the lesser the merchant is able to refuse accepting card payments. Put differently, the merchant's bargaining power is decreasing in the fraction of payment card users. We can therefore identify two countervailing effects—one leading to higher merchant fees and one to lower merchant fees as more consumers prefer card payments. As such, it remains an empirical question which effect dominates.

There is another factor that should reduce the equilibrium merchant usage fees according to standard economic intuition: network competition. In a perfect competition environment the differences between fee levels could theoretically be driven to zero. Obviously, this is not what can be observed in reality. According to the [United States Government Accountability Office \(2009\)](#) merchants claim to have little choice in accepting the dominant credit cards because of sheer market power. And while there exists some competition among acquirers and the acquirer fee may be negotiated, even large merchants have no capacity to lower interchange fees and thus, in turn, very limited leverage over merchant usage fees. In contrast, the multi-party payment card networks claim that competition might even lead to an increase in the payment card network price; they argue that further network competition will lead to higher interchange fees, since the networks will have to compete for issuers. In this regard, analyzing the dynamics between the downstream and the upstream payment market promises further results.

Lastly, our model provides a rationale for the vast differences in merchant usage fees between merchant sectors based on the profit motive of the payment card network. The intuition behind this finding is that the payment networks extract a part of the economic rent of the merchants. Thus, the margins of the merchant and the payment

card network add up, which seems similar to the double marginalization of two subsequent monopolies. This raises the suspicion of a potential market failure. However, it remains unclear what might help to constitute socially optimal payment card prices or, on the other hand, a market failure. In order to evaluate the question of social optimality, a model of overall welfare would be necessary. Such a model would have to include the benefits and costs of consumers, merchants, and the payment network over a range of merchant sectors. Some of these benefits are quite hard to quantify. We have not constructed an overall welfare model in this particular study, but it appeared to be a worthwhile extension.

MERCHANT FEE DETERMINATION AND THE PROPENSITY OF CONSUMERS TO USE PAYMENT CARDS

3.1 INTRODUCTION

Matters concerning payment cards have proved a fruitful area of research because card usage has constantly increased in importance over the last decades¹ and being a network industry only a few card networks dominate the market, thus exhibiting substantial market power². Consequently, a large part of the literature has to date focused on potentially anti-competitive behavior, such as excessive or inadequate pricing (Wright, 2010b; Wang, 2010; Rochet & Wright, 2010) and self-imposed rules (Carlton & Frankel, 1995; Evans & Schmalensee, 1995; Rochet & Tirole, 2008). It has also been noted that there are differences among merchant sectors; some merchants may be willing to pay more for the payment service than will others. However, this fact has mostly been taken as a given, but has not been further explored via specific research endeavors (Rochet & Tirole, 2006a; Bolt & Tieman, 2008).

This article extends the scant literature (Langlet, 2009; Langlet & Uhlenbrock, 2011) on sectoral merchant usage fee differences by showing the influencing factors of the downstream market in a model with Cournot competition among merchants. It is an extension of the model by Langlet (2009) based on Cournot quantity competition between merchants and a constant elasticity demand function. This effort contradicts the result that the number of merchants in a sector plays a decisive role. Instead, the most relevant factors are price elasticity of demand as well as the fraction of card users. Most importantly, it shows that merchant usage fee is increasing in the fraction of cardholders and thus is in line with developments over the last decades. Further, an extension of the model investigates the possibility of card networks to market card usage among consumers. It shows that card companies have a vital interest in bringing consumers to use their cards in those certain sectors with low price elasticity of demand where merchants' profits are larger.

¹ According to Bolt & Chakravorti (2008b) the use of payment card for in-store purchases has increased from 43% in 1999 to 56% in 2005 (original source: American Bankers Association and Dove Consulting (2005)).

² Vickers (2005) notes that Visa and MasterCard share about two-thirds and one-third of the credit card market in the United Kingdom (UK), respectively, independent of whether measured in number of credit cards issued or volume of transactions. In the US, these two networks control 80% of the market (Wang, 2010, p. 86).

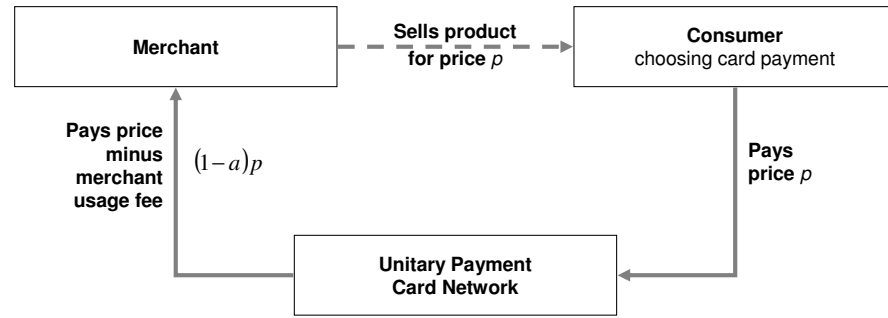


Figure 3.1: Organigram of a payment card network. Confer [Gans & King \(2003, p. 4\)](#).

The next section 3.2 lays out how the study relates to the current literature and motivates the analysis as well as the key assumptions. Section 3.3 presents the model and derives the main results for the downstream market, the maximum merchant usage fee that is acceptable in a specific sector, and the resulting influence on the price decisions of a unitary payment card network. Thereafter, section 3.4 presents a modification that allows the card network to induce consumers to selectively use their cards in certain sectors. Section 3.5 concludes the analysis.

3.2 KEY MOTIVATIONAL FACTS AND FINDINGS

3.2.1 Understanding Card Networks

There are two basic types of card networks: unitary (e.g. American Express, Discover) and multi-party (Visa, MasterCard). The workings of a unitary payment card market is shown in Figure 3.1. The merchant sells a product to the consumer at a given price. If the consumer decides to pay by card, he or she has to pay the full amount to the card network who then transfers the money to the merchant's account after deducting the merchant usage fee. In other words, in unitary networks there is only one financial institution that gets paid for handling the monetary transaction. In multi-party networks, in contrast, both consumers and merchants interact with their respective banks. The consumer's bank (issuer of the payment card) passes along the nominal amount to the merchant's bank (acquirer of payment transactions on the merchant's behalf). In this setup, there are two fees involved: the merchant usage fee that the merchant pays to the acquirer, and the interchange fee the acquirer pays to the issuer.

It is important to understand here that merchant usage fees and interchange fees are very closely related. The merchant usage fee is basically comprised of the interchange fee plus a small markup to cover the costs of the acquirer. Acquirers often claim they have little power over the merchant usage fee because of tough competition; they

are to a large extent simply passing on the network's interchange fee (United States Government Accountability Office, 2009; Schmalensee, 2002), a point of view that is widely accepted in many models (e.g. Wang, 2010; Wright, 2010a). In the end, interchange fees control the level of merchant usage fees, which is why, when merchants complain about excessive merchant usage fees as well as the high profitability of payment card providers (Chakravorti, 2010), researchers and regulators do not look at the merchant usage fee itself, but instead at the interchange fees. Accordingly, the payment card literature of the last few years has mainly focused on the question of whether interchange fees should be regulated or left to be decided by the marketplace (Weiner & Wright, 2005; Prager et al., 2009).

Many authors (Schmalensee, 2002; Rochet & Tirole, 2002) first argued there should not be any cost-based regulation of interchange fees, the reason being that payment card networks are a two-sided market where the price structure is not neutral. A two-sided market consists of a platform that serves two distinct customer groups, namely, consumers and merchants in the case of payment cards. The platform only functions properly and adds value when there is a sufficient number of customers on each side and the value of the platform for at least one customer group depends on the number of participants on the other side. This phenomenon is termed indirect network effect, and efficient pricing has to take these into account. Consequently, prices for one customer group may efficiently be below marginal costs if its presence adds significant value to the other customer side—a fact that can be observed in many two-sided markets (Bolt & Tieman, 2008).³ Since these first studies came out, other reasons for regulating interchange fees have been offered⁴ and fees are being regulated in several jurisdictions (Weiner & Wright, 2005).

Nevertheless, this regulation—where applicable—has so far not changed the important aspects of the price structure. Prices are heavily skewed toward merchants, while consumers do not have to pay. Without regulation, fee levels are often suspected of being excessive. Furthermore, it can be observed that card companies charge merchant usage fees proportionally to transaction values rather than a fixed amount per transaction (Board of Governors of the Federal Reserve System, 2010). Shy & Wang (2008) show that through this practice, card networks obtain higher profits and that the additional profit from proportional fees is burdened on merchants as consumer surplus remains unaffected. The rationale is that proportional fees are better

³ Skewed price structures are prevalent among many online services like search that are provided for free to users and paid for by advertisers.

⁴ The main problem being that consumers do not internalize the costs of their payment choice to merchants while merchants do internalize the value of the card usage to consumers Wright (2010b). Regulation could thus be based on the value to merchants of not having to handle cash Rochet & Tirole (2011) or not having to provide in-store credit in case of credit cards Rochet & Wright (2010).

adjusted to the value a merchant obtains through a purchase, and thus card networks can extract a larger share of this value.

This model takes as being exogeneously given these features of payment card networks rather than trying to explain them, as has extensively been done in the literature. Merchants have to pay a proportional merchant usage fee per card transaction, while consumers receive complimentary payment service. To simplify the workings of the card network, the model assumes a unitary network, so that it directly talks about merchant usage fees rather than addressing its most important component, the interchange fee.

3.2.2 *The Merchant Sector*

This study takes a particular interest in the role of the merchant sector for the determination of merchant usage fees since merchants pay substantially differing fees. According to the [United States Government Accountability Office \(2009\)](#) there are four main reasons for this difference:

1. Type of card: Credit cards are more expensive than debit cards
2. Merchant category: Sectoral differences translate into varying fees
3. Merchant size: Higher transaction volumes translate into lower costs
4. Processing mode: [PIN](#) versus signature cards, or online versus offline purchases are associated with different default or fraud risks

The academic discussion, however, has largely ignored this issue so that there is only scant insight into these four factors. Some models simply assume that there exists a difference in merchant valuation and derive a merchant's convenience benefit from card payments from some distribution function ([Rochet & Tirole, 2011](#); [Wright, 2004b](#)). Still, none of these studies actually try to explain the underlying reasons of these differences. Regarding the first reason given by the [United States Government Accountability Office \(2009\)](#), most models do not include the credit functionality of payment. [Rochet & Wright \(2010\)](#) show that providing credit obliterates the need for merchants to provide in-store credit, which can be provided more efficiently by banks. Other papers, including credit functionality, focus on the aspects of intertemporal business stealing ([Chakravorti & To, 2007](#)) or on the importance of the credit functionality to card users ([Chakravorti & Emmons, 2003](#)). Considering the value of credit to merchants, higher fees are justified not only from a cost perspective, but also from a value perspective since consumers are able to purchase more when provided credit.

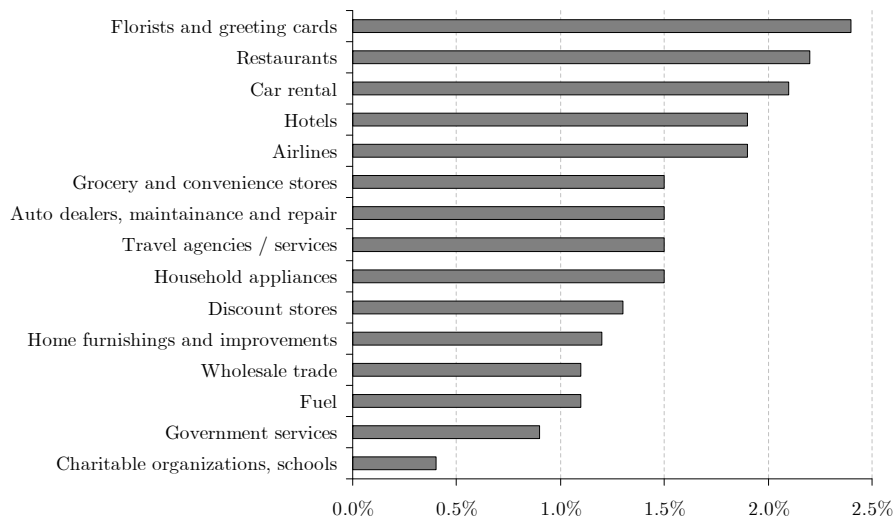


Figure 3.2: Weighted average merchant usage fee per type of merchant sector across EU, 2004 (European Commission Competition DG, 2006, p. 41, Graph 18).

The second reason, merchant category or sector, is the focus of this analysis. Third, merchant size mainly is concerned with the bargaining power of the merchant, so it is no surprise that larger merchants have more leverage in actual price negotiations. However, as the [United States Government Accountability Office \(2009\)](#) expressively notes, this leverage is still limited since acquirers claim that they are mostly passing on the interchange fee, over which they have no control. The fourth reason, different processing modes, is mostly technical, as different methods of authentication and usage are associated with specific default and fraud risks. Obviously, the higher the risk, the higher the merchant usage fee.

As this is the focus of this analysis, a few more words are in order here regarding the second reason, the merchant category or sector. As Figure 3.2 shows, there are substantial differences in merchant usage fee levels among merchant sectors. The figure shows the results of an antitrust investigation of the [European Commission Competition DG \(2006\)](#) regarding average fee levels in certain merchant sectors in the EU. The fees vary between 0.4% for charitable organizations to 2.4% for florists and greeting cards. While the former may be regarded as an outlier to support a good cause and could potentially represent true marginal costs of supplying the service, fees to gasoline stations are still only 1.1%, leaving a substantial variation among private merchant sectors.

In a specific merchant category, there are several aspects that could potentially influence the merchant usage fee. The overall size of the market, the number of merchants acting in that market, the related aspect of market power and competitive pressure, the price elasticity of demand, the possibility of merchants to differentiate their products

as well as the tendency to use payment cards in this sector are factors. So far, there are only two studies that have tried to investigate these factors to any major extent. This article builds on that literature.

Langlet (2009) derives in a similar setup that the merchant usage fee is dependent on the price elasticity of demand and the competitive environment of merchants. Taking into account the equilibrium effect of card acceptance, here we find different results for the last statement by taking into account how the additional transaction costs of payment cards affect overall equilibrium prices and quantities. Langlet & Uhlenbrock (2011) introduce Bertrand price competition between merchants to additionally study the effects of product differentiation. Using this setup, we find that the merchant usage fee is increasing in the downstream market size, but decreasing in the price elasticity of consumer demand as well as in the substitutability of products and the fraction of consumers preferring to make card payments. The intuition for the last result is that merchants increase prices if more consumers use card payments and overall sales then go down. In reducing the merchant usage fee, the payment card network tries to mitigate this effect. The approach taken in this model using Cournot merchants complements these results regarding the price elasticity of demand. Furthermore, it allows for a more detailed analysis of the role of the cardholder fraction.

3.3 THE MODEL

The model economy employs a unitary payment card network that services merchants in several sectors. In each sector, merchants can decide whether to accept payment cards as an additional method of payment or whether to simply accept cash. Different sectors can be characterized by a distinct number of competing merchants who have some degree of market power. There is an exogeneously given fraction of consumers γ who will only purchase if card payments are allowed. This reflects the fact that merchants experience increased sales if they accept card payments, and some consumers tend to buy more if they have a direct credit line available (Soman, 2001).

The timing of the game is as follows:

1. The unitary card network maximizes its profits by setting a merchant usage fee.
2. Merchants decide whether to accept card payments or not.
3. Merchants maximize their profits by deciding on sales quantities.
4. Consumers make their purchasing decision.

As always, the game is solved by backward induction.

3.3.1 The Downstream Market

Beginning at the last stage of the game, the basic setup of the downstream market follows the approach taken by [Langlet \(2009\)](#). The model deviates from his approach in the next section 3.3.2. Suppose there are several merchants with some market power who engage in Cournot quantity competition with homogeneous products. Merchant n faces the following constant elasticity demand function

$$p = Q^{-\frac{1}{\varepsilon}} = (q_n + q_{-n})^{-\frac{1}{\varepsilon}} \quad (3.1)$$

where p is the price, q_n is the quantity sold by merchant n , q_{-n} the quantity sold by all other merchants, so that Q is the total quantity, and ε is the absolute value of the price elasticity of demand.

Going back one stage of the game, assume there are N identical merchants in a given sector. Merchants incur the non-payment costs k for every good they sell. Consumers can either use a payment card for the purchase or use another method labeled as cash for simplicity. For the fraction γ of consumers who do use a payment card, the merchant has to pay a merchant usage fee a to the payment card network. The costs of handling cash payments are normalized to zero. Consequently, the profit function of merchant n is given by

$$\pi(q_n, q_{-n}) = (1 - \gamma) q_n (p - k) + \gamma q_n (p(1 - a) - k) \quad (3.2)$$

where the first part represents the profits from cash consumers, the second part is profits from card users considering both the merchant usage fee and the non-payment costs. After inserting the demand function (3.1), the profit function can be rewritten as

$$\pi(q_n, q_{-n}) = q_n (q_n + q_{-n})^{-\frac{1}{\varepsilon}} (1 - \gamma a) - q_n k \quad (3.3)$$

Profit maximization shows that the optimal quantity and price in the downstream market are influenced by the given factors

$$q_n^* = \frac{1}{N} \left(\frac{(1 - \frac{1}{\varepsilon N}) (1 - \gamma a)}{k} \right)^\varepsilon \quad (3.4)$$

$$p^* = \frac{k}{(1 - \frac{1}{\varepsilon N}) (1 - \gamma a)} \quad (3.5)$$

when assuming identical merchants choosing the same quantities $q_n = \frac{q_{-n}}{N-1} = \frac{Q}{N}$ and given that $\varepsilon > \frac{1}{N}$ for concavity.⁵ Proofs are relegated to the Appendix. For the whole market, this results in $Q^* = Nq_n^*$.

⁵ The concavity restriction appears innocuous as merchants with some market power will operate in the elastic spectrum.

3.3.2 The Highest Acceptable Merchant Usage Fee

Going one step back in the game, merchants have to decide on the payment methods they want to accept from consumers. The merchant only accepts card payments if his profits when doing so exceed the profits of only handling cash payments (Baxter, 1983; Schmalensee, 2002; Schwartz & Vincent, 2006).⁶ This assumption is different compared to Langlet (2009), where card sales are only required to yield a non-negative profit and ignore the overall effect of the merchant usage fee on both equilibrium price and quantity. The result is that the willingness to accept payment cards by merchants is thus overestimated.

In a no-card scenario, indexed nc , where only cash payments are allowed and the fraction γ of consumers do not make any purchases, the merchant's profits are given by

$$\pi^{nc}(q_n, q_{-n}) = (1 - \gamma) q_n (p - k) \quad (3.6)$$

leading to the equilibrium price and quantity of

$$q_n^{nc} = \frac{1}{N} \left(\frac{1 - \frac{1}{\varepsilon N}}{k} \right)^\varepsilon \quad (3.7)$$

$$p^{nc} = Q^{-\frac{1}{\varepsilon}} = \frac{k}{1 - \frac{1}{\varepsilon N}} \quad (3.8)$$

Given this scenario, there is a threshold for the merchant usage fee demanded by the card network under which merchants accept card payments. Again, assuming that merchants accept cards only in case the (net) benefit from doing so exceeds the (net) costs, there will be a Nash pooling equilibrium, where either all identical merchants accept payment cards or all do not. Setting the profits in these two cases as equal and solving for the merchant usage fee gives

$$\bar{a} = \frac{1 - (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma} \quad (3.9)$$

(3.9) defines the highest acceptable merchant usage fee \bar{a} . Note that the fee is independent of the number of merchants acting in a given sector and their non-payment related costs, but only dependent on the price elasticity of demand and the fraction of consumers who do insist on using a payment card. For these variables, the following relationship holds.

Lemma 3.1. *The highest acceptable merchant usage fee is decreasing in the price elasticity of demand and increasing (decreasing) in the fraction of consumers who pay by card for price elastic (inelastic) demand.*

$$\frac{\partial \bar{a}}{\partial \varepsilon} = \frac{(1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma \varepsilon^2} \ln(1 - \gamma) < 0 \quad (3.10)$$

⁶ Other authors have argued that merchants may even accept payment cards when the transaction costs exceed the transaction benefits in order to steal business from other merchants (e.g. see Hayashi, 2006).

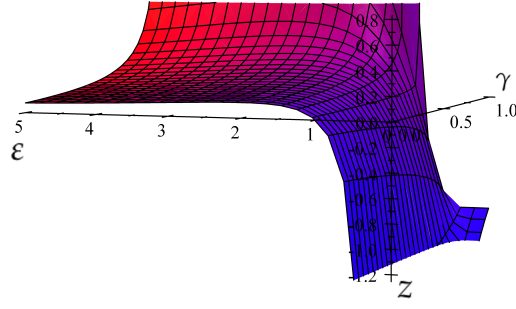


Figure 3.3: Relationship of the merchant usage fee threshold with respect to cardpayer's fraction $\frac{\partial \bar{a}}{\partial \gamma}$.

$$\frac{\partial \bar{a}}{\partial \gamma} = \frac{(1 - \gamma)^{\frac{1}{\epsilon} - 1} \left(\frac{\gamma}{\epsilon} + \frac{(1 - \gamma)^{\frac{1}{\epsilon} - 1} - 1}{(1 - \gamma)^{\frac{1}{\epsilon} - 1}} \right)}{\gamma^2} \quad (3.11)$$

The first statement holds because $0 < \gamma \leq 1$. The direct effect of the price elasticity of demand is negative, meaning that if the demand is more elastic, the maximum merchant usage fee that merchants are willing to accept will decrease. The reason is that merchants can pass on less of the fee to consumers and thus the merchants are more price sensitive themselves.

For the second statement, the sign depends on the price elasticity of demand, as can be seen from Figure 3.3. The figure shows the value of the derivative for different values of γ and ϵ . At unit elasticity, the derivative is zero ($\frac{\partial \bar{a}}{\partial \gamma} = 0$). Furthermore, the value changes from negative (for inelastic demands $\epsilon < 1$) to positive (for elastic demands $\epsilon > 1$). A positive relation means that if the fraction of card users increases, merchants are willing to accept a higher merchant usage fee and vice versa. The intuition for why the effect can go in both directions is that there are two effects of an increase in cardholders. First, having more cardholders gives merchants access to more consumers when they accept card payments, but secondly, there are more consumers for which the merchant has to pay the merchant fee. The end result depends on which effect dominates. As this model is concerned with merchants that have some measure of market power, these merchants will operate within elastic demands, and thus there will be a positive effect of more card users on the highest acceptable fee.

The result is to some degree affected by the assumption that consumers altogether shun shops in which they must pay cash. In reality, there are some consumers who would pay by card given the opportunity to do so, but who will still purchase the good even if they have to

pay cash. Given this somewhat looser second interpretation, the effect of an increase in the fraction of cardholders on merchant willingness to pay would be less positive. The reason is that merchants would have to pay the merchant usage fee for all these consumers, while not incurring additional sales. Accordingly, given these assumptions, the positive relationship is rather overstated than understated.

3.3.3 The Unitary Card Network

In the first stage of the game, the monopolistic unitary card network maximizes its profits Ω by setting the merchant usage fee. Its revenues are given by the turnover merchants make that are paid for with a payment card multiplied by the merchant usage fee. For parsimony, the network's fixed costs are normalized to zero as well as its marginal costs, which are negligible. The network's profit maximization problem is thus represented by

$$\Omega = \max_a \gamma a p^*(a) Q^*(a)$$

The network anticipates the decisions made by consumers and merchants. Inserting the equilibrium values into the maximization problem gives

$$\Omega = \max_a \gamma a \left(\frac{(1 - \frac{1}{\epsilon N})}{k} \right)^{\epsilon-1} (1 - \gamma a)^{\epsilon-1} \quad (3.12)$$

Setting the derivative $\frac{\partial \Omega}{\partial a} = 0$ equal to zero and solving for a yields

$$a^* = \frac{1}{\gamma \epsilon}$$

This merchant usage fee maximizes the network's profits. However, this maximum is not always obtained. As seen in the preceding section, the fee may not surpass the threshold $a \leq \bar{a} = \frac{1-(1-\gamma)^{\frac{1}{\epsilon}}}{\gamma}$. Consequently, the merchant usage fee can take on two different values. It is either the highest acceptable fee the merchant accepts or it is at the level where it maximizes the network's profits. That claim leads to the following proposition.

Proposition 3.1. *The optimal merchant usage fee is given by*

$$a = \min \left\{ \frac{1-(1-\gamma)^{\frac{1}{\epsilon}}}{\gamma}, \frac{1}{\gamma \epsilon} \right\}.$$

The optimal merchant usage fee is depicted in Figure 3.4 given elastic demands. It is the lower envelope (solid line) of the two terms given in Proposition 3.1. The figure shows two examples of merchant usage fees for different elastic demands (blue and black lines). For low γ , the constraint of the highest acceptable fee level is binding and thus

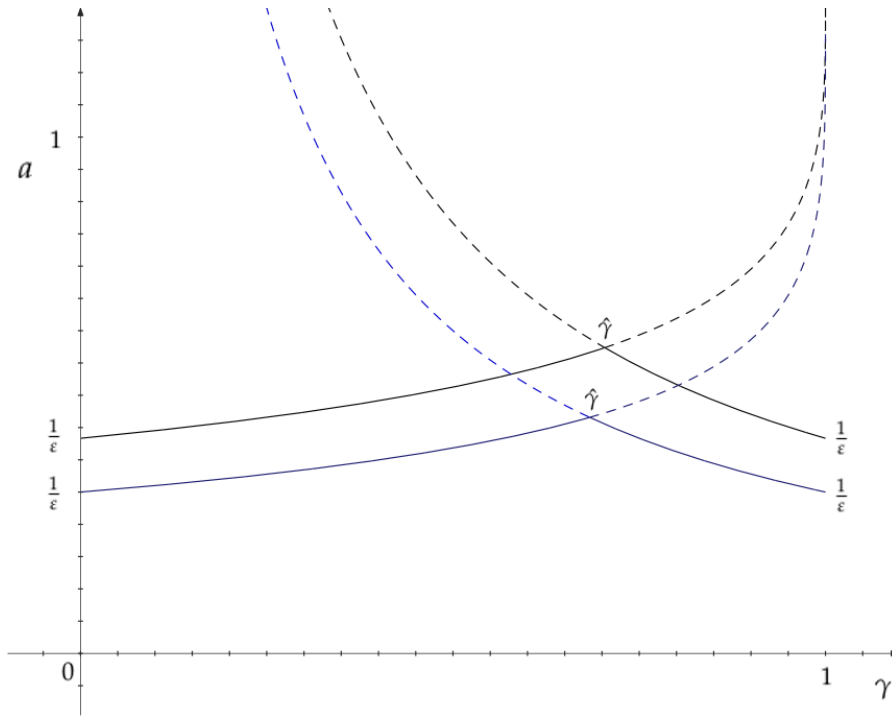


Figure 3.4: Optimal merchant usage fee the unitary card network imposes given elastic demand.

$a = \frac{1-(1-\gamma)^{\frac{1}{\epsilon}}}{\gamma}$. The optimal merchant usage fee then follows an inverse V-shape. It increases in γ until the threshold of $\hat{\gamma} = 1 - (1 - \frac{1}{\epsilon})^{\epsilon}$ is reached. The threshold is the point where the two terms are equal and lead to the same result. For higher γ , the constraint is not binding, and the merchant usage fee decreases in γ . The threshold $\hat{\gamma}$ itself is decreasing in the price elasticity of demand.

This finding is consistent with the notion provided by many merchants according to the [United States Government Accountability Office \(2009\)](#). When payment cards were not as widespread as they are today, accepting cards increased a merchant's revenues, which outweighed the higher costs of the merchant usage fee compared to handling cash. However, over the last decade, fee levels gradually increased, and at some point the additional costs outweighed the benefits of accepting card payments. According to the model findings, merchant fees should then decrease in equilibrium even without the regulatory intervention that is now being considered in many countries.

3.4 MODEL VARIATION

3.4.1 *Payment Cards Versus Other Payment Instruments*

The model thus far has focused on the determination of merchant usage fees—the price. The second aspect that affects a network’s revenues is quantity. The question arises then why consumers sometimes prefer payment cards over other instruments, such as cash or checks, and how a card network can influence the frequency of usage. Based on the Survey of Consumer Payment Choice conducted by the Federal Reserve of Boston on a regular basis since 2003, [Schuh & Stavins \(2010\)](#) find that credit cards are used because of low relative costs and high convenience. In order to tackle the cost aspect, card issuers have offered several reward programs: Cash-back, frequent flyer miles, and gifts. In the [US](#), these programs were introduced over 25 years ago, and today all top 10 issuers accounting for more than 80% of the aggregate market share offer rewards according to [Ching & Hayashi \(2010\)](#). In other countries (e.g. Australia, Mexico), however, the use of rewards had to be significantly reduced after regulatory intervention occurred to reduce interchange fees ([Bradford & Hayashi, 2008](#)). Interchange fee revenues, of course, pay for the generous reward programs the issuers offer, and [Dawson & Hugener \(2006\)](#) find that the costs of consumer rewards make up around 44% of interchange fees.

[Ching & Hayashi \(2010\)](#) investigate how the existence of reward programs influences the choice of the payment instrument, using the 2005/06 Study of Consumer Payment Preferences conducted by the American Bankers Association and Dove Consulting. Reward programs for credit cards are generally found to increase perceived ease of use, comfort, and safety for all consumers and thus change consumer attitudes toward the card. Using a multinomial logit model based on consumer preferences and perception, they also estimated the probability of consumers to use a specific payment instrument in five different retail categories: Grocery, department, discount, drug, and fast food stores. Their model suggests that removing rewards for credit cards would reduce the usage of credit cards by 3.3 percentage points in fast food stores (smallest change) and by 11.4 percentage points in grocery stores (largest change) in case debit cards do not offer rewards. If both debit and credit cards offered reward programs that were both removed, the credit card usage would decrease by 2.6 and 4.8 percentage points, respectively. These findings suggest that reward programs do change consumer perception and lead to increased card usage, but with differing impacts depending on the merchant sector.

[Carbó-Valverde & Liñares-Zegarra \(2009\)](#) provided a general overview of the sales impact of rewards and bonus programs. Using the marginal effects of a logit estimation, they find that rewards programs always have a statistically significant positive impact on card usage. Overall,

the probability of using a card increases by 3.8% through rewards programs—with cashbacks showing a larger marginal effect (4.1%) than gifts (2.7%), bonus points (2.3%), and discounts (1.5%). [Simon et al. \(2010\)](#) undertook a similar analysis for Australia based on consumer diaries of payment behavior in 2007. They did find that the probability of a consumer to use a payment card is 45% if the card network offers a reward program, while it is only 22% if such a program is not offered. Consequently, after the Australian regulator limited interchange fees in 2003, and issuers had to lower their reward programs, the growth of credit card use significantly reduced there. In contrast, [Chang et al. \(2005\)](#) found no significant reduction, but did assert that usage has mainly shifted from the regulated Visa and MasterCard systems to the unregulated American Express and Discover cards. In essence, the effects seem to be consistent.

In conclusion, reward programs seem to play an influential role when consumers make a choice for a specific payment instrument, and it is not surprising that card networks try to use this insight. Similarly, the choice of the payment instrument is influenced by the cost of usage ([Schuh & Stavins, 2010](#)). This aspect is apparent in the chosen price structure where consumers in general are not charged at all. Furthermore, the literature suggests that card networks offer reward programs to change overall perception and usage pattern. On top of this, they also try to single out specific merchants and merchant sectors where they explicitly want to encourage card usage, such as providing insurance for vacation bookings or offering special rewards programs with all major rental car companies. These practices could be due to strategic cooperations with large and important merchants as well as competitive aspects that enhance the attractiveness of the merchant sector itself similar to the preceding analysis. The next section further explores this possibility.

3.4.2 Unitary Network with Sector Specific Usage

This section discusses a variation of the model presented in section 3.3. The payment card network is able to adjust its merchant usage fee per merchant sector. On the issuing side, however, the consumers that it attracts can use the payment card in any sector. As [Ching & Hayashi \(2010\)](#) have pointed out, this usage is sector specific to some degree because of the differing importance of perceived characteristics and costs. Furthermore, they have shown that the propensity to use a card can be significantly influenced through reward programs. Nevertheless, this aspect only covers the user perspective. A similar argument can be made from the perspective of a card network. There may also be sector specific characteristics that make some sectors more attractive to the card network than others. By offering tailor-made rewards, such as insurance on vacation bookings, or extra bonus miles

when booking with major car rental companies, card networks are able to creatively target these attractive sectors.

Suppose that the payment card network has the ability to influence the propensity of cardholders to use their card through described marketing methods. Denote the propensity of card owners to use their card in a specific sector with $s \in (0, 1)$. This variable now is sector specific, while the fraction of cardholders γ is assumed to be identical across the sectors. Along the lines of the previous section, the equilibrium quantity and price in each sector is then given by

$$Q^* = \left(\frac{(1 - \frac{1}{\varepsilon N}) (1 - s\gamma a)}{k} \right)^\varepsilon \quad (3.13)$$

$$p^* = \frac{k}{(1 - \frac{1}{\varepsilon N}) (1 - s\gamma a)} \quad (3.14)$$

and the maximum merchant usage fee can be denoted as

$$\bar{a} = \frac{1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}}{s\gamma} \quad (3.15)$$

Suppose that the network is able to set the maximum merchant fee for both merchant sectors. Now, the network maximizes

$$\Omega = \max_{a,s} s\gamma (ap^*(a) - c(s)) Q^*(a) \quad \text{s.t. } a = \frac{1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}}{s\gamma} \quad (3.16)$$

where $c(s)$ denotes the costs of the marketing measures used for every purchase with a payment card. This additional cost component mainly alters the profit calculation compared to the previous maximization problem (3.12). Inserting $p^*(a)$, $Q^*(a)$ and a into the maximization problem and rearranging yields

$$\begin{aligned} \Omega = \max_s & \left(1 - (1 - s\gamma)^{\frac{1}{\varepsilon}} \right) (1 - s\gamma)^{1 - \frac{1}{\varepsilon}} \left(\frac{1 - \frac{1}{\varepsilon N}}{k} \right)^{\varepsilon - 1} \\ & - s\gamma c(s) (1 - s\gamma) \left(\frac{1 - \frac{1}{\varepsilon N}}{k} \right)^\varepsilon \end{aligned} \quad (3.17)$$

Taking the derivative with respect to s , setting it equal to zero, and simplifying the equation then gives

$$\begin{aligned} 0 = & 1 - \left(1 - \frac{1}{\varepsilon} \right) (1 - s\gamma)^{-\frac{1}{\varepsilon}} \\ & - \left(\frac{1 - \frac{1}{\varepsilon N}}{k} \right) ((1 - 2s\gamma) c(s) + sc' (1 - s\gamma)) \end{aligned} \quad (3.18)$$

This equation implicitly defines $s(\varepsilon, \gamma, k, N)$. In other words, the card network wants to influence the propensity of cardholders to

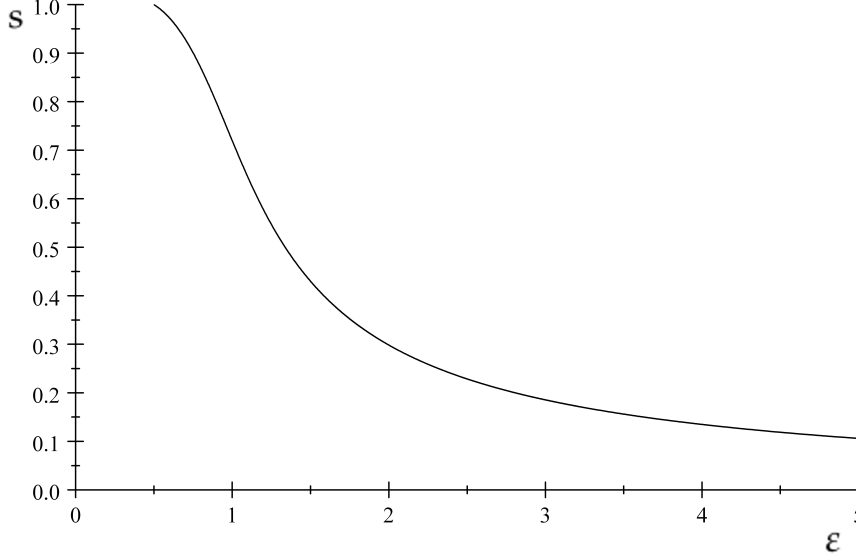


Figure 3.5: Propensity to use the card as a function of the price elasticity of demand for $k = 1$, $N = 2$, $\gamma = \frac{1}{2}$, $c(s) = -\ln(1-s)$, $c'(s) = \frac{1}{1-s}$.

use the card, given particular merchant sector characteristics. Figure 3.5 depicts this relationship given that $k = 1$, $N = 2$, $\gamma = \frac{1}{2}$, $c(s) = -\ln(1-s)$, $c'(s) = \frac{1}{1-s}$. The chosen graph gives a common representation of the general problem.

As one can see, the payment card network will invest less marketing activity in those sectors where the price elasticity of demand is lower compared to sectors where it is higher. This result is quite logical in and of itself, but it also highlights the double marginalization aspect of the card network. In profitable sectors where consumers do not react strongly to price changes, additional revenue from cardholders brings merchants increased profits that are, however, 'taxed' by the card network.

The assumption that γ represents cardholders who only purchase goods if they are allowed to use their card captures the effect that consumers have been shown to spend more with their cards and revenue for merchants rises. With their marketing expenditures, card networks are assumed to be able to influence this aspect indirectly as well through the mere extent of the card usage. To the degree that networks are unable to target specific sectors but do have to introduce general rewards programs, there is likely to exist a cross-subsidization between the sectors. Rewards programs lead to increased card usage that result in increased sales and revenues across the board. However, the costs of these programs are overly borne by more profitable sectors while the others also benefit.

How does this affect the spread of merchant usage fees across sectors? In section 3.3 it was shown that if there are only few cardholders, the merchant usage fee is increasing in the fraction of cardholders.

In this region, increasing the fraction, especially in sectors where the merchant usage fee is already high (sectors with a low price elasticity of demand), will exacerbate differences across sectors. On the other hand, when there are already many cardholders, the opposite effect prevails. Then, the merchant usage fee is decreasing in the fraction of cardholders. Convincing more people to use their cards in high-price sectors will narrow the difference in fee levels among all the sectors.

3.5 DISCUSSION AND CONCLUSION

This paper extends the scant literature on why merchant usage fees vary across merchant sectors based on downstream market characteristics. There is a monopolistic unitary payment card network and merchants engage in Cournot quantity competition. In contrast to previous works, this model shows that the fee level is independent of the number of merchants in the given sector. The difference stems from the consideration of the transaction costs of payment card services on overall equilibrium prices and quantities. Instead, this paper finds the merchant usage fee decreases in the price elasticity of demand and follows an inverse V-shape with respect to the fraction of cardholders. If there are only a few cardholders, increasing card usage increases the value to merchants because more consumers drive up the revenues. However, at a certain point, the higher costs of card transactions outweigh this benefit, and merchants will only accept lower fees.

Following this logic, it is easy to understand why merchant usage fees have increased over the years rather than decreasing because of the economies of scale and the lower transaction costs incurred by card networks. At some point, merchant usage fees should decrease when card usage becomes ever more widespread—even without regulatory intervention. Nevertheless, in this setup the payment card network resembles a government that provides payment services and taxes some of the profits, leading to a double marginalization effect. Accordingly, one can make the argument that in order to prevent harmful double marginalization, merchant usage fees should be reduced to a certain degree.

An important assumption of this study is that the merchant usage fee is efficiently set for each merchant sector. [Rochet & Tirole \(2002, p. 558\)](#) note, however, that merchant heterogeneity introduces an externality among merchants that exacerbates the difference in sectoral fee levels. If interchange fees are reduced for those merchants with a high resistance to merchant usage fees (e.g. supermarkets), issuer banks receive on average a lower interchange fee. In other words, costs to issuers increase, and accordingly, the average value of holding a card increases for consumers, so that other merchants are more inclined to accept higher fees to service these consumers. The overall

effect is that sector differences should be even stronger than predicted using this analysis.

The model variation analyzes marketing activities by card networks to increase card usage. In order to maximize profits, the networks try to skew card usage toward sectors with low price elasticity of demand that can be more heavily taxed. Depending on the fraction of cardholders, this effect could either exacerbate sectoral merchant usage fee differences, or it could lead to fewer differences. So far, these activities have only been looked at from the user's perspective, exploring the factors that incline consumers to use certain methods of payments or others. Using this knowledge about consumers, card companies have tried to win the patronage of consumers. The model here employed may help explain the rationale of card networks to do so.

Part III

SMART METERING

HOW TO REGULATE A MARKET-DRIVEN ROLLOUT OF SMART METERS? A MULTI-SIDED MARKET PERSPECTIVE

This chapter is joint work with Jan Schächtele.

4.1 INTRODUCTION

The security of the energy supply in industrialized and developing nations is regarded as a great challenge in the upcoming decades (IEA, 2010). The origin of this challenge lies in the emerging tension between growing energy demand and the need to reduce carbon dioxide emissions in order to keep the global climate stable. Key elements in the envisioned solution for a sustainable energy system are a strong improvement in energy efficiency and the deployment of distributed low-carbon energy generation. A concept often mentioned in this context is the smart grid—the intelligent electricity network. Smart grids help to better balance energy supply and demand and to increase operating efficiency of the grid. One crucial component of such smart grids is smart meters, which are intended to replace the conventional Ferraris meters that measure the electricity consumption of residential and small commercial consumers.¹

Although there is general consensus on the contribution of smart meters to higher energy efficiency and to the integration of renewables, a comprehensive smart meter rollout has so far been conducted in only two countries—Italy and Sweden. To accelerate its adoption, the European Parliament and the European Council target an 80% coverage for all EU member states by 2020 in their third energy package. The EU directive, however, does not specify how this national rollout should be carried out. Member states can choose between a mandated or a market-driven approach. Countries such as Germany favor the market-driven approach, as they believe this will result in lower rollout costs and higher consumer cooperation, which is important to increase energy efficiency (Bundesnetzagentur, 2010b). Far from being restricted to Europe the market-driven smart meter rollout is also relevant for many other nations, such as the USA or China, where no state directives are yet in place.

¹ Throughout the document we refer to electricity meters when using the term smart meter. We are, however, aware that some types of smart meters can also measure natural gas and water consumption. Furthermore, the term consumers always refers to residential and small commercial consumers. Large commercial consumers usually face different incentive structures and are therefore in large parts already equipped with meters allowing real-time pricing.

One of the key economic obstacles to a market-driven smart meter rollout is the split of benefits among all stakeholders.² According to [McKinsey \(2010\)](#) “fragmentation across the value chain has reduced the incentive for any single player to invest in smart meter[s].” The complexity is further increased through characteristics of the electricity market. As [Hogan \(2001\)](#) noted, “electricity systems present complicated challenges for public policy [...] in providing a balance between regulation and markets, public investment and private risk taking, coordination and competition.” For instance, providing the grid infrastructure is a textbook example of a natural monopoly due to the high fixed costs. Consequently, some form of regulatory intervention is required even for a market-driven rollout. In this paper, we highlight an additional complication since we identify the operation of smart meters as a multi-sided market, which interlinks the market sides through indirect network effects.

Taking into consideration the key insights from the multi-sided market literature, the focus of this paper is to systematically analyze how to best regulate the smart meter market assuming the regulator favors a market-driven rollout.³ Therefore, the goal of this paper is threefold. First, we demonstrate that the smart meter market is multi-sided for every market structure. Second, we apply the lessons learnt from multi-sided market economics to the different market structures. Third, we identify the superior market structure and its best regulatory design to overcome the investment barrier. As the paper assesses potential smart meter market structures in general, the insights are, however, not limited only to the rollout but are also applicable to the general regulation of the smart meter market. Furthermore, because of this generality the analysis is not limited to any specific national energy market regulation.

The rest of this paper is organized as follows. Section 4.2 starts with an introduction to the smart meter market and an analysis of costs and benefits of a rollout. Furthermore, it discusses why a market-driven rollout might be preferable to a mandated rollout. Afterwards, section 4.3 demonstrates that the smart meter market fulfills the requirements of a multi-sided market. Building on this, some implications for pricing are outlined. The actual analysis of the optimal regulation for a market-driven smart meter rollout begins in section 4.4 with an assessment of the possible market structures. Section 4.5 continues the analysis by identifying the best regulatory design option to yield the benefits

² There are further obstacles such as stranded assets (replaced Ferraris meters before end of lifetime), no clearly defined technical standards or low consumer awareness of advantages of smart meters ([European Smart Metering Alliance, 2009](#)). These obstacles, however, can be regarded as preconditions for any type of smart meter rollout.

³ To the best of our knowledge nobody has so far conducted a similar analysis. [Baringa \(2009\)](#) assessed different smart meter market structures but focused on a mandated rollout and the particularities of the UK market.

of a market-driven smart meter rollout. Section 4.6 indicates possible regulatory modifications, and section 4.7 concludes.

4.2 SMART METER MARKET

In this section we describe the smart meter market. The description starts with an introduction to the functionality of smart meters and continues with an overview of the relevant stakeholders and their interconnections. Then, we analyze the costs and benefits of the smart meter implementation for the different stakeholders and conclude with advantages and disadvantages of a market-driven rollout.

4.2.1 *Advanced Meter Infrastructure and Stakeholder Landscape*

The core functionality—making a meter smart—is communication. In addition, electronic metering and data storage are basic functions that go beyond the capabilities of a conventional electricity meter. A common term for the entire set of relevant technical components and the comprehensive functionality of a smart meter platform is Advanced Meter Infrastructure (AMI). Taking into consideration the definitions of the [Federal Energy Regulatory Commission \(2008\)](#) and [Nabe et al. \(2009b\)](#) we define AMI for our context as a system that meters and stores a consumer’s electricity consumption and potentially other power quality parameters in short time intervals and communicates this information to a central data collection point from which it is also capable of receiving data.

Beside the basic functions of the AMI, smart meters themselves can have additional features such as detection of fraud, remote disconnect and connect functions, or load control to manage specific devices such as electric hot-water heaters and air conditioners ([Bundesnetzagentur, 2010b](#) and Department of Energy and Climate Change ([DECC](#)) and Office of Gas and Electricity Markets ([OFGEM](#)), 2011). Building on its functionality AMI also enables new applications. First, it allows for the introduction of variable tariffs.⁴ In this way, electricity prices for consumers fluctuate depending on supply and demand and, thus, the market mechanism is implemented. Second, on a larger scale, it is envisioned as an essential device for the future integration of distributed energy generation—mainly in the form of renewables—and energy storages ([IEA, 2008](#)).

The stakeholders relevant to a smart meter implementation correspond to stakeholders in the traditional electricity market. They are schematically depicted in Figure 4.1, which identifies six relevant stakeholders: four key stakeholders (retailer, Distribution System Op-

⁴ There is a large variety of potential tariff structures. The two major categories are: Time-variable or load-variable tariffs. For a comprehensive overview on the topic of variable tariffs we point to [Neenan et al. \(2005\)](#) and [Nabe et al. \(2009a\)](#).

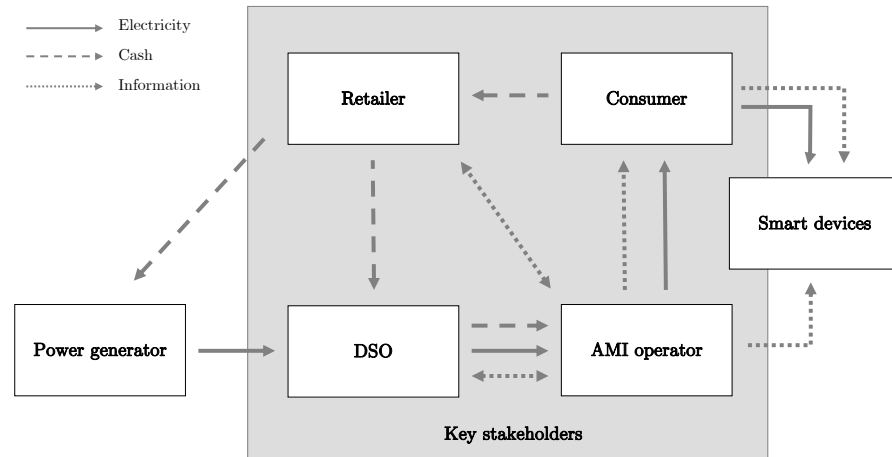


Figure 4.1: Stakeholders of the smart meter market.

erator (DSO), meter operator (labeled as AMI operator), and consumer) who are directly affected by a smart meter implementation and two that perform (essential) additional functions (power generator and smart devices).⁵ Note that for the description of the smart meter market we do not take into account ownership but simply focus on the functions performed. Supplementary, the figure shows three levels of interaction between the stakeholders.

The first level is given by the physical delivery of electricity. Electricity is generated by a power generator and then transferred via the grid of the DSO⁶ to the consumer. A meter controlled by a meter operator measures consumers' electricity consumption. As illustrated in the figure, a part of the consumption might be due to smart devices, whose functionality is described later.

Consumers do not interact with all stakeholders in the delivery chain. Instead, they simply buy electricity from a retailer, who coordinates this task for them.⁷ The payment process indicated by the second level of interaction in the figure reflects the role of retailers. The consumer pays the retailer for all services she has used: her electricity consumption, access to the electric grid, and the metering service. Supposing a liberalized market, the retailer himself purchases the marketed electricity from a power generator and passes the other

⁵ Note that we present a sample case and that the market setup varies from country to country, e.g. in the US there are additional stakeholders such as the Independent System Operator (ISO), or the Regional Transmission Organization (RTO). However, these alterations of the market structure would not affect the main findings of our analysis but mainly alter the allocation of benefits discussed in the next section.

⁶ The transmission of electricity from the power generator to the DSO often also requires a Transmission System Operator (TSO), which covers the long distance transmission from the side of the power generation to the local DSO. However, the TSO is not an important player in the smart meter context.

⁷ Consumers in some countries—for instance in Germany and the UK—also have the option to contract an independent meter operator to measure electricity consumption.

fees on to the DSO. The DSO then keeps an amount for providing the infrastructure and passes on the metering fee to the meter operator.⁸

In addition to these two traditional levels of interaction in the electricity market, smart meters add a third level of communication among the different stakeholders. There is a two-way information flow between the smart meter and both the retailer and the DSO. In addition, consumers obtain information such as electricity consumption or billing rates through home displays or computer programs. Finally, the smart meter communicates with consumers' smart devices that can be turned on by the consumer but can also be managed remotely.

4.2.2 *Costs and Benefits*

Several interested parties have tried to list and quantify the potential costs and benefits of a smart meter rollout for residential consumers. In this section we provide a short overview of this literature. With respect to a monetary evaluation we focus on three comprehensive studies, which provide estimates per installed meter on a yearly basis. Two of them were conducted for national agencies—Mott MacDonald (2007) for the British Department of Business, Enterprise and Regulatory Reform and Nabe et al. (2009b) for the German Federal Network Agency—, whereas the last by A.T. Kearney (2008) was written from a business perspective.⁹ Additionally, we consider the qualitative descriptions of costs and benefits by Frontier Economics (2007). All values and descriptions following in this subsection have been taken from these sources. An important insight is that the variance and degree of uncertainty is higher for the benefits of smart meters than for the corresponding costs. This is particularly true for consumer benefits, which not only depend on existing consumption levels, but also on the degree of adaption in behavior. In contrast, the observed scope in rollout costs originates mainly from the variety in technologies available. We start the overview with a description of the benefits for the different stakeholders before looking at the cost side.

Apart from qualitative improvements such as fewer blackouts and no involvement in meter reading, consumers profit from a smart meter through (potentially) lower energy bills. One lever to lower the energy bill is the above-mentioned variable tariffs that encourage consumers to move their electricity usage to periods with lower prices. This consumption shift can actually be automatized with smart devices. Thus, even if overall consumption remains the same, electricity costs can be

⁸ In many countries, however, the DSO and meter operator are the same company, so no settlement takes place between them.

⁹ Note that the quantitative assessment—in contrast to the generally applicable qualitative statements—is determined by distinctive regional characteristics (consumption patterns, climate, market structure etc.). The focus of the three selected studies is on Germany and the UK, so that the given values can be regarded as an illustrative example for a European nation with moderate climate.

reduced by avoiding peak hours. Another lever is the visualization of energy consumption in order to reduce total consumption. Consumers are sensitized to their consumption patterns and can use the available information to identify electricity guzzlers. Moreover, because of accurate metering, consumers pay directly for their real consumption and are not billed based on (usually higher) estimates. All in all, these benefits per smart meter per year as calculated by the three mentioned sources vary substantially between €4.5 (Germany) and £5.5 (UK)¹⁰ at the lower end and €34 (Germany) at the upper end, largely depending on the degree to which consumers (are able and willing to) adapt their behavior.

The benefits for retailers can be divided into two big groups: more efficient operation and closer customer relationship. A strong driver of efficient operation is the reduction of process costs. Smart meters allow for remote deactivation in case of a move and inter-period meter reading, reducing the organizational effort and staff required for these processes. Furthermore, they increase the quality of the consumption data. The better data quality reduces the workload and mistakes in the billing process, lowering the interaction with consumers in order to handle complaints. In addition, smart meters enable better encashment through constant monitoring, which diminishes the likelihood of bad debts. Finally, if consumers switch their consumption to periods with low prices as a result of variable tariffs, retailers can reduce the cost of procuring electricity.¹¹ In addition to the cost impact, variable tariffs also allow for a better customer relationship. Retailers can offer consumers new tariffs reflecting their individual consumption patterns, thereby taking into account their needs. Leveraging the increased availability of consumption data can also support relationship building. Retailers can bill more frequently and offer supplementary services such as energy consulting to consumers. All in all, retailer benefits are expected to be in the range of €4 in Germany and £8.1 in the UK.

The main benefit for the DSO addresses the quality dimension. Smart meters allow for a better and faster detection of outages. Furthermore, they monitor energy quality and consequently help to reduce voltage fluctuations. On top of the quality aspect, there are also minor reductions of process costs. The maximal grid load is lower, resulting in lesser line losses, potentially lower cost of the reserve energy, and a reduction of future grid investments. Assuming real load profiles, smart meters increase the precision of consumption forecast planning and completely eliminate the need for estimates of energy consumption to determine grid usage fees. Finally, smart meters enable the

¹⁰ The value for the UK does not include savings from variable tariffs.

¹¹ The increased operating efficiency is first of all a benefit for retailers, but competition should force retailers to pass on a large portion of these benefits to consumers. In this case early-adopters among retailers only acquire a competitive edge whereas decreased electricity prices due to more efficient operation can be regarded as a consumer benefit.

detection of fraud. Overall, these benefits are estimated at about €2.5 in Germany and £1.5 in the UK.

The meter operator profits from reduced operating costs since the entire process of meter reading is streamlined. Only limited personnel are required. The planning of the reading process is facilitated as no appointments with consumers have to be arranged. The quality of data is increased, lowering the process costs as described above. The total savings from these process improvements are estimated to amount from €3.5-4 in Germany to £6.5 in the UK.¹²

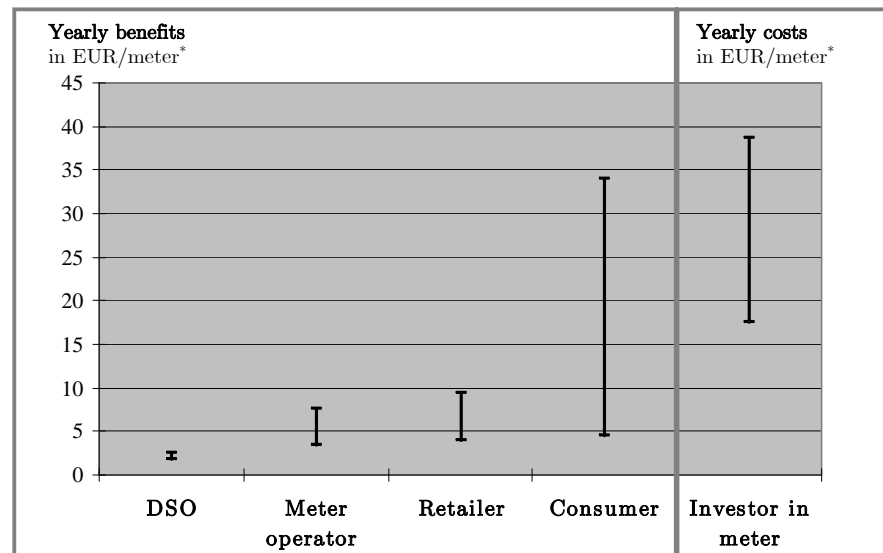
All mentioned studies identify the same major cost elements: the smart meter costs (with respective communication modules), the installation costs and the operating costs. Furthermore, Information Technology (IT) costs are named but not always specified. Our quantitative cost assessment, however, is based solely on Nabe et al. (2009b) as this is the only study that provides comparable annualized costs.¹³ Contrary to the benefits, we also do not allocate smart meter costs to any specific stakeholder since, as we show in section 4.4, there are several potential owners depending on the chosen market structure. For smart meter investment and installation, annualized costs per meter are calculated in a range between €14-31. The variation arises because of the different types of meters (modular versus integrated meters) and the communication technology used. For each smart meter type a minimum, maximum, and middle annualized cost is provided. The above range is taken from the middle values only, thus the overall cost range is even larger. Operating costs are not calculated explicitly in the study, but a factor of 25% of the annualized capital costs is assumed, yielding a corresponding range of operating costs between €3.5-7.8.

Figure 4.2 depicts the ranges of costs and benefits of the smart meter rollout from the three different studies. The range of yearly benefits per meter are displayed separately for every stakeholder. This is contrasted with total yearly costs per meter in the right column. It can be seen that for most cases there are too few incentives for single stakeholders to invest in smart meters, even if it is beneficial overall—as indicated in the introduction.¹⁴ We take this monetary evaluation as given and analyze how to address and overcome the investment barrier in sections 4.4 and 4.5.

¹² Note that the reading interval in the UK is 2 reads per year compared to 1 read in Germany. Thus, the savings potential per read is nearly identical.

¹³ We avoid making assumptions about amortization periods and interest rates in order to annualize the cost of the two other studies.

¹⁴ Counterexamples are given by Italy and Sweden. In Italy, a vertically integrated utility was able to capture all listed benefits plus savings from large reductions in electricity theft. In Sweden, the state simply decreed—for political reasons—monthly billing and thus artificially escalated process costs with conventional meters and implicitly enforced smart meters. For details see NERA Economic Consulting (2008) and Wissner (2009).



* In order to convert £ to €, an exchange rate of 1.1659 (average of 2010) is assumed.

Figure 4.2: Costs-benefits comparison for smart meter rollout.

4.2.3 Advantages and Disadvantages of a Market-driven Rollout

The comparison of costs and benefits in Figure 4.2 also shows that there is a wide bandwidth of potential costs and benefits, and for some consumers costs exceed benefits. Thus, marginal costs would be larger than marginal benefits for some consumers even when taking into account network effects. If this is the case, a comprehensive rollout that forces every consumer to install a smart meter is not cost effective. Furthermore, a comprehensive rollout leads to higher governance costs in order to enforce state regulation (Baringa, 2009). The danger of inefficiently inflating the cost base is a strong argument for a market-driven rollout approach.

The second strong argument in favor of a market-driven smart meter rollout is based upon the fact that if every consumer has to make a conscious decision for the installation of a smart meter, the probability that consumers adapt their behavior increases. Specifically, as consumers' benefits can be heavily influenced through the degree of adaption. The Bundesnetzagentur (2010b) and DECC and OFGEM (2011) underline in their reports that the education of consumers is a critical element to be addressed, since the simple installation of the smart meter does not make any major contribution to energy efficiency in itself. Only if consumers are aware of the potential and optimize their behavior, can the complete benefits of smart meters be locked in.

In contrast, there are also arguments against a market-driven smart meter rollout. First, a state-mandated comprehensive rollout could lead to economies of scale. Second, it could accelerate the learning curve. Third, it would allow for density advantages through a street-by-street installation. All of these factors could potentially reduce rollout

costs (Baringa, 2009; Wissner & Growitsch, 2010). In addition, a state-mandated rollout approach secures target achievement (Wissner, 2009). On the one hand, the critical mass of consumers to yield the benefits will be surpassed. On the other hand, the rollout will be conducted in a predefined time period. Finally, Wissner & Growitsch (2010) argue that if consumers underestimate the savings potential from using a smart meter, they would have an inadequately low willingness to pay. In such a case, a state-mandated rollout could remedy this shortcoming for these consumers, however, at the expense of forcing smart meters onto consumers for whom costs exceed benefits as outlined above.

The discourse about state-mandated versus market-driven rollout is yet undecided. We purposefully do not make any judgement on this matter. For the rest of the paper, our premise is that the regulator favors a market-driven rollout—for whatever reason—as is the case in Germany.

4.3 ADVANCED METER INFRASTRUCTURE AS A MULTI-SIDED MARKET

The focus of this section is on an applied review of the multi-sided market literature. This means we do not conduct the review as a discrete section, but, where possible, directly link the findings to the smart meter market described above. At first, we specify the defining properties of a multi-sided market. Additionally, we show that each of these properties applies to the smart meter market.¹⁵ Then, we elaborate on the characteristics of a multi-sided market and their implications for the setting of prices.

4.3.1 *Definition of Multi-sided Markets*

There is no uniform definition of multi-sided markets in the literature. Rather, several requirements or properties are identified that define a multi-sided market. Consequently, we conduct our analysis of the multi-sidedness of the smart meter market along a set of defining properties.

The first fundamental requirement for a multi-sided market is the provision of goods or services by a “platform” to at least two distinct groups of customers (compare among others Rochet & Tirole, 2003; Armstrong, 2006). These customers need each other in some way, but frequently the products, which the “platform” offers to the distinct customer groups, differ. The term platform is not narrow, but leaves space for many types of businesses. Classical examples are night clubs or dating companies providing services to men and women; or credit cards enabling consumers possessing a card to pay with electronic cash,

¹⁵ Müller et al. (2010) identify the smart grid as a two-sided market, but to the best of our knowledge nobody so far identified the AMI as a multi-sided market.

and merchants accepting them to get access to this consumer group. In the case of the smart meter market, retailers, consumers and DSOs are possible customer groups of the AMI platform. Furthermore, each of them receives a different service or good from the AMI. Retailers obtain prompt consumption data and can offer variable tariffs and reduce process costs. Consumers gain access to electricity and expect monetary and qualitative benefits. DSOs receive information on the stability and quality of the power distribution.

Another requirement for a multi-sided market is the failure of the Coase theorem (Rochet & Tirole, 2002). In the case of smart meters, the transaction costs of negotiations would be extremely high due to the large number of involved agents. Taking the example of Germany there are over 30 million households, roughly 850 DSOs and over one thousand retailers in the competitive electricity market (Bundesnetzagentur, 2010a). Negotiations are further complicated through a competitive retail market since it multiplies the number of possible DSO-retailer combinations. Competition in the electricity retail market is a requirement for EU member countries (Percebois, 2008) as well as applicable to several states in the US and Australia (Brennan, 2009). High switching rates of electricity consumers in several countries and states (e.g. 47% in Great Britain, 32% in Sweden, 45% in Victoria, Australia, 36% in Texas, US according to Defeuilley, 2009) demonstrate that it is reasonable to assume competition in the electricity retail market.

A further precondition of multi-sided markets (see e.g. Armstrong, 2006) are indirect network effects. According to Evans (2009, p. 5) “indirect network effects exist when the value that a customer on one side realizes from the platform increases with the number of customers on the other side.” In other words, the customer group on one market side exhibits positive externalities for the other market sides, and—as with all network effects—these positive externalities increase with the number of participants. These indirect network effects occur in the smart meter market. The more consumers join the AMI platform, the higher the value of platform access for retailers and DSOs. Retailers increase their operating efficiency the more, the higher the coverage of smart meters. This is because the adjustment of internal processes is characterized by high upfront costs and low variable costs so that potential benefits increase with the customer base. In contrast, the benefits of a closer customer relationship due to smart meters are hardly affected by indirect network effects. DSOs profit the more from information on stability and quality of the power distribution, the higher the coverage of data points. Apart from the quality dimension, the monetary benefits of DSOs are also influenced by indirect network effects. Both savings due to lower maximal grid load and savings related to real load profiles increase with the number of consumers on the other side of the AMI platform. In case of an increased number of retailers, one can argue that consumers profit from the greater range

of products (different tariffs matching their individual needs better) and the intensified competition, which leads to lower prices. Whether DSOs profit from an increased number of retailers, or the other market sides profit from an increased number of DSOs, seems unlikely.¹⁶

According to Evans (2009) and Hagiu (2009) another characteristic of multi-sided markets is the performance of at least one of three core functions to some degree. The first two reduce search costs. Here, the platform can either serve as matchmaker, facilitating the interaction when more than one market side is searching. Or by contrast, the platform may support building of audiences in case of single-sided search, thereby increasing the chances of an adequate match. In terms of the third core function, the platform potentially acts as a shared resource during the transaction, which reduces the cost of services for all market sides. Although many multi-sided platforms engage in all three functions to some degree, a focus on one function is not uncommon (Evans & Schmalensee, 2007b). The AMI platform is mainly about operating as a shared resource. Its communication infrastructure is required by all market sides in order to exchange information. Consequently, a common platform reduces the cost of service for each market side. Additionally, one could argue that the AMI engages in building audiences. The more consumers have access to the AMI platform, the more attractive the provision of variable tariffs for retailers becomes. With respect to matchmaking, the contribution of the AMI is rather limited.

Taking into consideration the three core functions above, a further typical property of multi-sided markets follows naturally. Evans & Schmalensee (2007b) state that multi-sided platforms minimize transaction costs for the market sides, thereby permitting value-creating exchange. This statement is easily applicable to the smart meter market. Without the AMI platform, the constant exchange of information between stakeholders in the electricity market would not be economically feasible. The effort and time needed for all market sides would be too high. Only AMI enables frequent data exchange at reasonable prices. That this exchange is value-creating for all stakeholders is described in detail in section 4.2.2.

Summing up, we come to the conclusion that the AMI fulfills the criteria of a multi-sided market. It serves several market sides with different products and the number of involved agents rules out efficient negotiations. At least one market side exhibits indirect network effects. Additionally, the AMI platform performs the core function of a shared resource, thereby reducing transaction costs for all market sides. Thus,

¹⁶ It is not necessary that all market sides exhibit indirect network effect in order to be classified as a multi-sided market. A classical example of two-sided markets frequently used in the literature are advertising-supported media such as newspapers or magazines. Here, advertisers value more readers, but readers most likely not value more adverts. Compare Evans (2009) and Hagiu (2009).

it enables a value-creating exchange, which is only feasible with the [AMI](#).

4.3.2 *General Résumé from the Literature*

Having established that an [AMI](#) platform represents a multi-sided market, we discuss implications stemming from this finding in this section. There are several relevant peculiarities of multi-sided markets that need to be considered in the context of smart meters. Whenever meaningful, we explain the respective peculiarity by looking at other illustrative multi-sided markets.

The first peculiarity deals with the establishment of multi-sided markets. By definition, a platform operator needs to get at least two market sides on board, otherwise the platform will not be valuable to anyone. This task is specifically complicated by the fact that the positive externalities have a network character, meaning that a critical mass of participants is needed to begin with. Combined with a need to make a fixed upfront investment in the platform infrastructure it, therefore, poses a challenge to get a multi-sided market going. This phenomenon is typically referred to as a chicken-egg problem ([Evans, 2009](#)). In order to facilitate the market-driven emergence of the smart meter market, the German Government, for example, has made it obligatory for retailers to offer variable tariffs (see *Energiewirtschaftsgesetz* (Energy Industry Act) ([EnWG](#)) Section 40(3)). Thereby, one side of the market is encouraged to participate by law, which in turn is supposed to increase the attractiveness of the [AMI](#) platform for consumers.

[Rochet & Tirole \(2003\)](#) identify a related peculiarity that needs to be considered to get both market sides on board. They argue that it is crucial for platform operators not only to determine the price level but also the price structure—which market side has to pay how much for the service. This notion contradicts the standard result of microeconomic theory about the neutrality of price structure.¹⁷ Thus, businesses in multi-sided markets devote much attention to how the cost burden is allocated. The result is that in many multi-sided markets one market side pays a higher price than the other side irrespective of underlying marginal costs ([Evans, 2009](#)). For instance, online search is commonly provided free of charge, while advertisers pay fees for every user clicking on their ad.¹⁸

Consequently, other factors—on top of production costs—need to be considered when specifying the efficient price structure in a multi-sided market. The most prominent of these factors is the positive

¹⁷ The introduction of a sales tax is an example for the neutrality of price structure, as it leads to a new market equilibrium which determines to what extent the burden of the tax falls on each market side—consumers or merchants—independent of who is obliged to actually pay it.

¹⁸ Other examples include ladies-night in discos and nightclubs, or free-to-air television and radio.

externalities among market players (Wright, 2003). As discussed in section 4.3.1, consumers exhibit indirect network effects on the other market sides of the smart meter market. Accordingly, the price structure should reflect these benefits and the other players should shoulder some costs of consumers (European Smart Metering Alliance, 2009). Besides, Armstrong (2006) argues that the best way to internalize the indirect network effects is to use a pay-per-transaction scheme rather than to have a fixed fee for access to the platform. This way, every time the other market side actually benefits from the positive externality, it has to pay for it and thus best internalizes it.

An additional factor relevant for the price structure is potential obstacles for certain market sides. In the smart meter market consumers face difficulties in assessing their true savings potential (compare Commission for Energy Regulation, 2011, for a field study with Irish consumers). With conventional Ferraris meters, prices consist of a relatively complex combination of metering charges and electricity prices, but consumers have only a limited overview of their consumption pattern. If they switch to smart meters, fixed metering charges will increase, whereas variable electricity tariffs and consumption information allow for savings. Under such vague circumstances, risk-averse consumers may need further inducements to invest. Furthermore, the literature discusses consumer myopia, which leads consumers to be biased towards current over future payoffs (Gabaix & Laibson, 2006). Inducements could help to counterbalance these consumers' biases. Thus, both factors—indirect network effects and obstacles—suggest a benefit transfer from other market players to consumers. Thereby, the investment barrier, which was identified as a key obstacle for the market-driven rollout, could be overcome through a rebalancing of benefits as consumers would have sufficient incentives to invest.

Finally, there is another phenomenon with respect to a socialization of costs that is relevant in the smart meter context. Taking the well-studied case of credit cards as an illustrative example, processing card payments is more costly for merchants than processing cash payments. Nevertheless, payment networks have imposed a no-surcharge rule prohibiting merchants from charging higher prices for card payments compared to cash payments.¹⁹ In other words, the costs of the payment card system are socialized over all consumers and this leads to more card usage in equilibrium.

There has been some discussion about whether or not such socialization is beneficial in the credit-card market²⁰, but for the smart meter

19 No-surcharge rules are forbidden in some jurisdictions, but empirical evidence is available suggesting that even in the absence of no-surcharge rules most merchants demand the same prices (ITM Research, 2000 and Chakravorti & To, 2007).

20 Rochet & Tirole (2002) find in a theoretical setup that a no-surcharge rule can be welfare enhancing or reducing. While the theoretical result is ambiguous, Guibourg & Segendorf (2004) and Bolt et al. (2010) have argued, based on empirical results, that the socialization of costs is socially beneficial in the case of credit cards.

market, three arguments favor a socialization of costs—meaning to let owners of conventional Ferraris meters share part of the smart meter costs. The first argument is that some of the benefits of smart meters are also socialized. If DSOs can reduce their investments into grid capacity, and retailers can monitor consumption more efficiently and thus avoid costs, this reduces overall prices for all consumers. The same socialization of benefits is also true for major qualitative improvements such as less blackouts. Thus, if some benefits are socialized, so could some of the costs. The second argument is based upon the limited market knowledge of consumers. Because of indirect network effects and economies of scale, average costs in the whole smart meter market are reduced if many consumers install smart meters. Individually, consumers do not take this into account. For this reason, there is more likely to be an underprovision of smart meters absent any regulatory incentives. In addition to these two arguments, a socialization of costs could help to overcome the chicken-egg problem in this particular market as it reduces investment barriers. The main argument against socialization is based on the fact that it induces a cost increase without choice for those consumers who do not switch to smart meters. This has to be observed critically from an equity perspective. However, it appears that the advantages of socialization of cost outweigh the disadvantages.²¹

Summing up, multi-sided market economics provides some key insights for the regulation of the smart meter market. Wright (2004a) recognized that being unaware of these insights can lead to typical regulatory fallacies. The most relevant fallacy in the smart meter context is the assertion that an efficient price structure should reflect the relative cost of service for each customer group. In contrast, multi-sided market economics reveals that there is a rationale to transfer some of other market participants' benefits to consumers and that this benefit transfer is best based on a per-transaction basis. On top of that, there are reasons for the socialization of costs so that even consumers who stick with their old Ferraris meters share in the smart meter costs. A second relevant fallacy is the idea that an increase in competition necessarily results in a price structure that better reflects the relative cost of service for each customer group. This is generally not true for multi-sided markets. An optimal price structure is independent of the level of competition.²² Thus, we can apply the same general lessons learnt to different market structures independent of the level of competition. This is what we do in the following analysis of potential smart meter market structures.

21 Socialization of costs is not uncommon in environmental regulation, compare for example feed-in tariffs to promote renewable energy sources.

22 However, competition has other beneficial effects such as high cost pressure.

4.4 MARKET STRUCTURE ANALYSIS

In this section we apply the insights from multi-sided market economics to the potential smart meter market structures. This is important as the chicken-egg problem as well as the pricing structure have a strong influence on the emergence of a market. Consequently, when analyzing the optimal regulation for a market-driven smart meter rollout they have to be considered. Before starting the analysis, we first explain why regulation is required independent of the type of market structure and then present the potential market structures.

4.4.1 *Potential Market Structures*

From a public policy perspective, it is difficult to determine the extent to which the market structure development can be left to the free market and this has been a constant struggle for regulators around the world (Joskow, 2008b). An important reason for this is the fact that one crucial market player—the DSO—is running a natural monopoly and, consequently, is acting under regulatory oversight. In other words, the DSO is not free to independently perform business strategies that might otherwise be spontaneously developed in a free market environment. Thus, the regulator intervenes to some degree even when the smart meter market is liberalized. We argue that an informed decision about how to intervene should take into account the lessons learnt from multi-sided market economics.

For the purpose of the analysis we view the stakeholder that is operating the AMI as the defining element of a market structure. The regulator can either select one market side to operate the smart meters or liberalize the market and leave the process of determining the operator to the market. From the key stakeholders identified, three could potentially perform this function and, in fact, are asked to do so in different countries: (1) retailers, (2) (independent) meter operators, and (3) DSOs.²³ For illustrative purposes they are depicted in Figure 4.3. Remember that we suppose a competitive retail market; a definitive objective of regulation in the EU and also applicable in some states in the US and Australia.

In the first market structure, the regulator only allows retailers to operate smart meters. When consumers then switch their retailer, they automatically switch their meter operator. Hence, retailer competition and metering competition are identical in this market structure. This case is comparable to the UK. The second market structure is the result

²³ The UK opts for establishing a unified data and communication provider that supports retailers in their function as AMI operators (DECC and OFGEM 2011). This can be regarded as another way of implementing a unified communication standard but it does not reflect another market structure as defined in our approach. Additionally, we rule out the case that every consumer runs her own AMI due to the immense transaction cost.

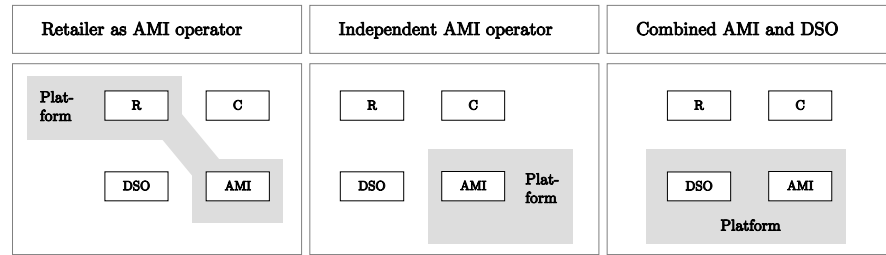


Figure 4.3: Potential smart meter market structures.

of a complete meter market liberalization as attempted in Germany. Whoever wants to enter the market is allowed to do so and can compete for consumers. To stringently distinguish market structures, we assume that ownership of the independent meter operator does not play a crucial role. In other words, in the competitive environment of the second market structure, the results of our analysis are independent of whether the meter operator is owned by a retailer, a DSO, or any third party. In the third market structure the regulator simply extends the natural monopoly of the DSO in the grid market to the meter market as is done in Sweden and Italy. Note that we compare idealized forms of market structures in order to conduct a thorough analysis and that in reality hybrid forms can also emerge in which the observed differences blur.

There are also two commonalities among all market structures. Firstly, all market structures allow for a limited reduction of obstacles for consumers by addressing the investment costs of the smart meter. This can be achieved through two different channels: the state or retailers. Since the increase of energy efficiency due to the installation of smart meters reduces carbon dioxide emissions, governments may be interested in providing monetary incentives to consumers for the installation of smart meters.²⁴ Thereby, governments would pay for the more efficient achievement of carbon dioxide emission reductions that could be obtained by a smart meter rollout. In contrast, retailers have a different motivation. The installation of smart meters allows for the offering of new products, which gives access to new consumer groups, and also has the potential of reducing operating costs. Consequently, a partial transfer of the investment cost from consumers to retailers is possible in the course of consumer acquisitions. Secondly, a definition of communication standards is required independent of the chosen design option.²⁵ The communication standard ensures that all stakeholders in the smart meter market can consistently exchange

²⁴ Some economists argue that states should only define an emission target and introduce an emission trading scheme. carbon dioxide reductions should then be left to the market mechanism and therefore states should not provide any subsidies (for an overview of the discussion see Fischer & Preonas, 2010).

²⁵ The definition of a standard data format for communication was a key element of the Swedish smart meter rollout (Wissner, 2009) and Italy and Great Britain for example

data. Only if this is the case, retailers serving consumers from different distribution grids can generate the greatest possible benefits from the implementation of smart meters, which can then (partly) be passed on to consumers in the form of lower prices for electricity.

In the following, we assess each of the three market structures with respect to five common evaluation criteria that reflect classical regulatory considerations of static and dynamic efficiency as well as aspects resulting from multi-sided market economics. In more detail, this means we investigate whether a market structure provides incentives for operating efficiency and meter innovation; regarding multi-sided market implications, we examine whether the chicken-egg problem can be solved by overcoming the investment risk and/or socializing some of the costs, and analyze whether the right price structure can be imposed in order to account for the positive externalities that consumers exhibit. These positive externalities are the benefits for the retailer, and the [DSO](#) described in section [4.2.2](#).

Note that depending on the market structure, these benefits are either internalized through the operation of the [AMI](#) platform itself or a benefit transfer between market sides. For instance, if retailers operate the [AMI](#), their benefits are internalized through the platform operation. If another stakeholder operates the [AMI](#), the retailer—who is now a market side to the platform—passes on the same benefits, but denoted as indirect network effects. We keep this distinction in nomenclature for the sole reason of being consistent in the analysis of multi-sided markets.

4.4.2 *Retailer as Advanced Meter Infrastructure Operator*

Suppose that retailers operate the [AMI](#) infrastructure independent of who operates the conventional meters. This means that retailers serve consumers on one side of the platform and the respective [DSO](#) on the other side. As already indicated above, we also suppose retailers act in a competitive environment and consumers can easily switch their retailer. As a result, the operation of smart meters happens under competitive conditions as well. Thus, every retailer has good reasons to improve the operating efficiency of the [AMI](#). In addition, retailers have incentives to innovate in the market and offer new products and services that go beyond the standard functions in order to tie consumers. Another aspect of retailer competition is that the benefits of the retailer mentioned in section [4.2.2](#) are then passed on to consumers through the competitive pressure to lower prices.

On the downside, retailers are not well equipped to deal with the chicken-egg problem that is essential in a market-driven rollout. One way to get the consumers on board is by socializing some or all of the

are thinking about the implementation of communication standards ([Nabe et al., 2009b](#)).

smart meter costs. In that case, all existing consumers bear the cost of the AMI infrastructure, not just those who actually install such equipment. At best, some retailers could exploit the fact that they are the default providers of electricity in an area and that switching retailers involves transaction costs. Thus, socializing investment costs is feasible as long as prices for all consumers increase only slightly. Nevertheless, because retailers have to act in a competitive environment, this option is limited.

Another way to induce consumers to install smart meters involves the AMI operator (in this case the retailer) taking on some of the investment costs of the smart meter and then recovering the investment over time. This business strategy suffers from a typical holdup problem as an investment risk results from the fact that consumers can easily switch retailers. Thus, retailers are hindered in covering part of the investment costs of consumers, which creates a major hurdle for market entry.²⁶ The European Smart Metering Alliance (2008) sees evidence of this in the UK's unbundled market, where retailers are anxious to invest for fear of stranded assets when losing customers to the competition. But because retailer competition is regarded as an important element of the liberalized electricity market (NERA Economic Consulting, 2008), it is not desirable to reduce this competitive pressure in order to increase investment security.

Another downside covers a further challenge of multi-sided markets. We have stated that other market participants should pay for the indirect network effects (positive externalities) they receive from consumers' participation. This appears to be difficult for the case of the DSO. The DSO is currently being regulated to provide the grid infrastructure in a cost-efficient manner. The regulator would have to adjust this regulation to account for the benefits the DSO receives and reduce prices—potentially a delicate task. Even if this can be achieved to some extent, several cost reductions materialize for all consumers rather than for individual consumers who decide to invest in a smart meter. This is because of the nature of the benefits (enhanced quality, lower maximal grid load, reduced investment in energy generating capacity etc.) that can hardly be allotted to individual consumers. The grid benefits are thus socialized, while the investment costs remain private.

As a result, we find that the cost pressure on retailers fosters operating efficiency and innovation. However, such a market struggles to materialize. Because of the high investment risk, due to the competitive meter market and the inability to socialize the AMI costs, retailers have difficulty in overcoming the chicken-egg problem. Furthermore,

²⁶ Another perspective to this issue is based on transaction costs. Retailer ownership of smart meters increases transaction costs when consumers switch retailers. If retailers are burdened with these costs to ensure a competitive retail market, then retailers will be hesitant to invest.

the price structure in this market is not optimal as grid benefits can hardly be passed on to consumers.

4.4.3 *Independent Advanced Meter Infrastructure Operator*

The second possible market structure relies on an independent [AMI](#) operator, which is the consequence of a liberalized smart meter market. This independent operator could act as a subcontractor to a retailer or a [DSO](#) or be completely independent from the other market participants, but as outlined above we assume that ownership does not matter. In any of these cases, the platform would then have three market sides: supplying advanced electricity consumption data to the consumer, the [DSO](#), and the retailer. We could accordingly speak of a three-sided market. If meter operation is the only service an independent operator is offering, the incentives for operating efficiency and [AMI](#) innovation would be larger than in any other case since this is the only value proposition such a business could offer.

This biggest strength, however, is also a weakness with regard to the economics of multi-sided markets and solving the chicken-egg problem. In effect, because meter operation is all the [AMI](#) operator is offering, there is no chance of letting other consumers with old meters share in the investment cost. The market's cost pressure would not allow for a strategy of socialization. The market competition also translates into a certain investment risk. Independent [AMI](#) operators could offer longer-term service contracts to consumers, take on the investment costs and recoup them over the contract period. This business strategy would theoretically be feasible because switching the retailer would still be possible without switching the meter operator. However, it would reduce the investment risk for operators only to a limited extent, as increasing prices for meter operation is a difficult task when entering a new competitive market.

With respect to indirect network effects, the retailer benefits are passed on to the consumer through competition in the form of lower electricity prices. Here, retailers are one side of the market. To that effect, the positive externalities consumers exhibit on retailers are being paid for by retailers. For the benefits of the [DSO](#), nothing changes in comparison with the first market structure. In fact it is difficult to pass on their benefits to consumers—especially to the respective consumers who make the investment. Those [DSO](#) benefits that are passed on are rather shared by all consumers.

All in all, this market structure suffers from similar problems as the first option. The investment risk and lack of socialization still complicate a market-driven rollout. Furthermore, the price structure is not optimal as not all indirect network effects are accounted for. However, the competitive environment creates strong innovation incentives and

cost pressure for retailers and [AMI](#) operators. Thus, overall, this makes for a more attractive market structure than the first alternative.

4.4.4 *Advanced Meter Infrastructure and Distribution System Operator*

As discussed earlier, running the electricity grid is a natural monopoly. On top of that, [DSOs](#) in most countries have traditionally held a monopoly on operating meters in their area. Therefore, it is natural to suppose a monopolistic [DSO](#) running the [AMI](#) infrastructure. In that case, we face a monopolistic combined Advanced Meter Infrastructure and Distribution System Operator ([AMI-DSO](#)) that enables retailers and consumers to exchange information.

Thus, there is less pressure for high operating efficiency and to innovate because of a lack of competition ([Jamasb & Pollitt, 2001](#) and [Baringa, 2009](#)). These are important reasons why some countries have tried to break up this monopolistic position and introduce competition in the meter market.²⁷ However, the economics of multi-sided markets also reveals significant advantages of this market structure.

The first advantage is that all benefits identified above are accounted for. The retailer's indirect network benefits are passed on to the consumer through competition, and the [DSO's](#) benefits are internalized because it is operating the [AMI](#) platform. Both players can thus pass on these benefits to individual consumers to entice them to invest in smart meters. For the retailer, this will naturally happen through competition just as in the other market structures. For the [DSO](#), this involves regulation, which is easier to perform in this market structure than in the others. When regulating the prices that are set for the operation of smart meters, benefits and costs can be cleared and thus both elements will be accounted for.

Another positive aspect of acting in a monopoly is that investment risk is low. Ownership of the smart meter does not change, even if consumers change retailers. If [DSOs](#) act in a reliable legal environment where the long-term requirements for smart meters do not change, they can recoup their investment over a long period.

On top of that, [DSOs](#) could easily socialize the costs of smart meters to all consumers—those who have smart meters and those who do not. This is a critical aspect and we have already explained in section [4.3.2](#) why such a feature might be desirable in the context of a multi-sided market. Of course, the degree of socialization would have to be subject to regulation lest a complete rollout of smart meters with full functionality immensely drives up the costs.

Summing up, the biggest strength of this market structure is that it incorporates the characteristics of multi-sided markets, which facilitates a market-driven rollout. The chicken-egg problem is approached

²⁷ Examples are Germany, the [UK](#) and until 2010 the Netherlands ([European Smart Metering Alliance, 2009](#)).

	<div> <div>Plat-form</div> <div>R</div> <div>C</div> <div>DSO</div> <div>AMI</div> </div>	<div> <div>R</div> <div>C</div> <div>DSO</div> <div>AMI</div> <div>Plat-form</div> </div>	<div> <div>R</div> <div>C</div> <div>DSO</div> <div>AMI</div> <div>Platform</div> </div>
Market sides	Consumer, DSO	Consumer, Retailer, DSO	Consumer, Retailer
Incentive for operating efficiency	+	++	-
Incentive for innovation	+	++	-
Investment security	--	-	++
Socialization of cost	0	--	++
Benefit transfer for network effects	-	+	++
Platform operation internalizes benefits	++	0	+
Regulation required	DSO benefits	DSO benefits	Smart meter fee

Figure 4.4: Evaluation of smart meter market structures.

through socialization of costs and high investment security. Furthermore, an optimal price structure, which accounts for indirect network effects, provides investment incentives. This comes at the expense of a monopoly position for the AMI operator and, consequently, fewer incentives for operating efficiency and innovation.

4.4.5 Summary and Comparison

A summary of the different market structure characteristics can be seen in Figure 4.4. On the left, the different evaluation criteria are listed. The rest of the table summarizes how well the three potential market structures fare with respect to these criteria. Note that since the evaluation criteria are assessed qualitatively, it is not sensible to compare market structures by simply adding up given values. It is rather necessary to weigh the relevance of the different criteria and to make an informed decision based on this weighing.²⁸

The first column shows the retailer as the AMI operator. In this setup, there is an incentive for operating efficiency and innovation, but there is a high investment risk because consumers can easily switch retailers. A socialization of costs is only possible to a limited degree regarding the existing consumer base. The positive externalities consumers exert are internalized by the retailer in the operation of the platform but are difficult to grasp in the form of indirect network effects to the DSO. The latter would have to be regulated.

The liberalized smart meter market is evaluated in the second column. Here, incentives for operating efficiency and innovation are

²⁸ Assuming the regulator is mostly concerned with a market-driven rollout, the criteria with high relevance are investment risk, socialization of cost and accounting of indirect network effects.

largest, but investment security is rather low due to the difficulty in selling long-term contracts. There is effectively no possibility to socialize costs because companies are acting in a competitive environment. Positive externalities from consumers are internalized to a similar degree as in the first structure, albeit in a different fashion. The [AMI](#) operator cannot himself internalize benefits, but the retailer's benefits are passed on through competition. Again, the [DSO's](#) benefits are difficult to account for, even with regulation.

The combined [AMI-DSO](#) offers a different picture as shown in the third column. The low level of incentives for operating efficiency and innovation are clear disadvantages. On the upside, all positive externalities from the consumer are accounted for, and beyond that, a socialization of smart meter costs is feasible—if the regulator allows it. Furthermore, [DSOs](#) have a high level of investment security giving them an incentive to proceed speedily.

Summing up, the market structure analysis yields the result that having a combined [AMI-DSO](#) is best suited for a market-driven rollout of smart meters. Overcoming the chicken-egg problem is facilitated and it is possible to achieve a sensible price structure around the [AMI](#) platform. The characteristics of multi-sided markets are thus accounted for, albeit at the expense of having fewer incentives for operating efficiency and innovation.²⁹

4.5 REGULATORY DESIGN OPTIONS

Having identified the combined [AMI-DSO](#) as the most suitable market structure to account for the characteristics of multi-sided markets and thereby to foster a market-driven rollout of smart meters, there are four different design options with respect to a socialization of smart meter costs that the regulator can choose from. Remember that the decision whether to install a meter or not is with the market but the responsibility for the rollout lies with the [DSO](#) and thus the regulator needs to choose and directly allow for any level of socialization. In this section we analyze in how far each regulatory design option is appropriate to overcome the chicken-egg-problem and to yield the potential benefits of a market-driven smart meter rollout—cost effectiveness and consumer education. The four options, which differ only to the degree to which they allow for a socialization of costs, are:

- **No socialization of costs:** The individual consumer has to bear the full costs of the smart meter, meaning investment costs as well as operating costs.

²⁹ In case the regulator is mostly concerned about classical regulatory considerations instead of a market-driven rollout, the optimal market structure could, however, look different (see also discussion about time-inconsistent preferences in section 4.6).

- **Socialization of operating costs:** The individual consumer has to bear the investment costs of the smart meter; the (increased) operating costs, however, are socialized and distributed over all consumers of the respective DSO.
- **Socialization of investment costs:** The (increased) operating costs of the smart meter are billed to the individual consumer, whereas the investment costs of the smart meter are socialized and distributed over all consumers of the respective DSO.
- **Total socialization of costs:** Both investment and operating costs of the smart meter are socialized and distributed over all consumers of the respective DSO.

Before analyzing the different regulatory design options, it is meaningful to outline the characteristics all options have in common. Firstly, because of the combined AMI-DSO's natural monopoly the regulator has to define the cost base for the smart meter rollout. This includes the recognition of costs for the smart meter communication infrastructure for all regulatory design options. Additionally, it comprises a specification of cost components—operating and/or investment costs—that are to be socialized. For the case that the smart meter investment costs are socialized, it also requires a definition of a technical standard configuration with a respective limit of compensable costs, lest there be a complete rollout with the highest functionality the market offers. Secondly, the DSO, being the AMI operator, is in charge of the defined socializable smart meter investments. This means that the DSO not only pays for the smart meter communication infrastructure upfront, but depending on the design option, also for the smart meter itself. The compensation for these investments occurs through increased fees for meter operation in the upcoming years, which are billed to the retailers, who then (partly) pass the fees on to the consumers. Thirdly, consumers have a veto power in case of higher costs due to the installation of a smart meter. This veto power—defining the consumer as the decisive player—underlines the reliance on a market decision for smart meter implementation. But because it only applies if the consumer faces higher costs, it is ensured that the rollout is not slowed down in case a DSO has the capabilities for a cost-neutral rollout.³⁰

4.5.1 No Socialization of Costs

The first design option assigns the full cost burden to consumers. This means that most relevant decisions are driven solely by market forces, impacting the cost effectiveness of the rollout threefold. Firstly, the market decides on the degree to which smart meters are rolled out.

³⁰ The limited veto power, restricted to the case of higher cost, is already an element of the refined market-driven approach of the German Federal Regulatory Agency (see Bundesnetzagentur, 2010b).

No mandatory rollout targets are given by the regulatory regime or indirectly by the government. It is rather the conscious decision of every single consumer to opt for a smart meter. Secondly, neither is there a need to define a technical standard configuration with respect to the functionality of the smart meter. The market process will both demonstrate which features have real benefits for consumers or retailers and ensure that these are offered at reasonable prices. Consequently, the regulatory market intervention is limited to the communication standard and the cost of the communication infrastructure, which are both required for any design option. From this perspective, costs are kept low.

Thirdly, a potential downside with respect to cost effectiveness is the presumably large variety of smart meters in use—assuming a lack of a technical standard specification by the regulator. This could result in less specialization of technicians, which increases the time needed to identify and solve problems. Potentially, stocks of spare parts have to be increased, resulting in higher capital cost than necessary. Furthermore, the interoperability between different types of smart meters and the communication infrastructure could increase the complexity of the whole system, requiring a larger effort for smooth operation. Finally, there is a higher risk of investing into an island solution that would altogether retard the rollout process and increase costs.

Regarding consumer cooperation, the fact that every consumer has to make a conscious decision for the installation of a smart meter increases the probability that consumers adapt their behavior. Specifically, as the consumer's benefits can be heavily influenced through the degree of adaption. As discussed in section 4.2.2, the education of consumers is a critical element to be addressed, since the simple installation of the smart meter does not make any major contribution to energy efficiency in itself.

Whether the limited reduction of obstacles in this design option resolves the chicken-egg problem remains, however, questionable. Consumers will still be faced with a substantial amount of upfront investment and also face higher meter operating costs. The examples of countries with primarily market-driven rollouts, such as Germany and the UK (until 2008), support this negative conjecture. In both countries, the penetration of smart meters is low and numbers are not expected to increase quickly without adjustments to regulation in the upcoming years.³¹

³¹ The market-driven penetration rate of smart meters in the UK was only 0.5 % in 2007, so that the government at the end of 2008 decided in favor of a mandatory rollout until 2020 (see Wissner, 2009). There are hardly any smart meters installed in Germany yet and the installed ones are due to direct government mandate. But so far the German Federal Regulatory Agency adheres to a market-driven rollout and simply suggests to refine this approach (Bundesnetzagentur, 2010b).

Summarizing, a DSO in charge of the AMI infrastructure but no socialization of costs is similar to the status quo in Germany³², where the DSO still operates the majority of meters. The regulatory design option offers several advantages due to the strong reliance on market forces, but it struggles to generate sufficient incentives for consumers to overcome the investment barrier for smart meters.

4.5.2 *Socialization of Operating Costs*

The advantages of the second design option, in which a socialization of operating costs takes place, are similar to the ones in the first design option. It too relies heavily on market forces. Both the degree of rollout—as no mandatory target has to be enforced—and the optimal functionality of the smart meter are left to the market. Consequently, the only specified regulatory parameters are the communication standard and the cost limit of the communication infrastructure. Because of the market mechanism the cost effectiveness in this design option should be high, albeit with the caveat of having a large variety of smart meters in use. Since consumers have to make a conscious decision for a smart meter, chances for an adaption of consumer behavior are again high, as explained above.

However, with respect to the reduction of consumers' obstacles for investment there is a difference. This design option addresses the increase in operating costs resulting from the usage of a smart meter. Due to the socialization, the marginal consumer making a smart meter investment does not face any increase in operating costs based on her decision. Her costs are split among all consumers independent of whether they possess a smart meter or not. Considering that many consumers are switching to smart meters, the overall operating costs will, however, increase. Note that the result of this process is a lower fee for the operation of the smart meter for the individual consumer who invests in a smart meter compared to the first design option; assuming that not all consumers upgrade to the smart meter. Consumers deciding against the installation of a smart meter likewise face a cost increase as a consequence of the socialization of the operating costs—raising questions about equity as described in section 4.3.2.

It is evident that this design option does not completely eliminate the need for initial investments by consumers. The remaining investment costs are, therefore, still a potential barrier to a market-driven rollout. However, compared to the first design option, this barrier is lower, since the increase in operating costs is socialized.

Summing up, this regulatory design option leverages the power of the market leading to cost effectiveness and consumer cooperation, while it increases the incentives for the installation of smart meters by

³² However, the German regulator is trying to enforce competition and move towards independent AMI operators.

addressing operating costs. Thus, the need for an upfront investment by consumers is still present and must be regarded as a serious barrier to a market-driven rollout.

4.5.3 *Socialization of Investment Costs*

Socialization of smart meter investment costs, which is the third design option, has major differences to the two previous ones. Its biggest advantage is the full elimination of investment costs for consumers. The [DSO](#) is in charge of the smart meter investment, for which it gets compensated through adjusted future fees for the meter operation. Consumers still decide to opt for a smart meter, but the corresponding investment costs are socialized over all consumers of the respective [DSO](#). Accordingly, the marginal consumer only faces (slightly) increased fees for the meter operation, but no initial investment. However, the switching of many consumers leads to an additional increase in operating fees for all consumers conforming to the compensation of the [DSO](#) for the investment costs. This increase in operating fees is higher than for the previous regulatory design option, because of the larger annualized costs of the smart meter investment compared to the operating costs (see the smart meter cost split in section [4.2.2](#)). Thus, consumers not migrating to a smart meter are confronted with an even higher increase in operating fees.

Besides, the billing of operating fees for the use of the [AMI](#) platform to retailers and indirectly to consumers, reflects the logic of pay-per-transaction—which is one of the implications for the price structure from multi-sided market economics in section [4.3.2](#). Users of the [AMI](#) platform pay only for the platform when they actually benefit from it and thereby internalize the positive externality of the other market side. Translated into the context this means retailers and indirectly consumers pay only for the use of the [AMI](#) platform when a value-creating exchange between them takes place.³³

With respect to cost effectiveness, the continuing reliance on the market mechanism has to be evaluated positively. It is still the market that determines the degree of the smart meter rollout. The regulatory regime does not prescribe any mandatory rollout targets, but it is again the conscious decision of every consumer to opt for a smart meter. In contrast to the two previous design options, the optimal set of features, however, is not determined through a market-driven trial-and-error process, but defined by the regulatory regime. Only Extras on top of the defined standard are still available through the market.

³³ Obviously, this argument applies to consumers migrating to the smart meter. Consumers with conventional Ferraris meters pay higher fees but profit only to a limited degree.

Thus, the decision for the optimal meter is transferred from the market to the regulatory authority. Thereby, the regulator has to define the optimal functionality upfront for a certain period to generate investment security for the DSOs. This should reduce the variety of smart meters in use and thus have a positive impact on cost effectiveness. Beside the technical standard, the regulatory regime also has to set a cost limit for the envisioned standard meter.³⁴ Evidently, it is questionable whether the regulatory regime will always find the best solution and the correct price—a common problem of incentive regulation.³⁵

Since consumers go through a conscious decision-making process in favor of the smart meter, weighing increased operating costs against potential benefits from the installation, an adaption of the consumers' behavior can be anticipated. This is a prerequisite for the energy efficiency to increase.

To recap, this regulatory design option fully eliminates the upfront investment need for consumers, while it (greatly) conforms to the advantages of a market-driven rollout; market-driven because consumers with a smart meter face higher operating costs. Additionally, it also reflects the pay-per-transaction logic from multi-sided market economics. Thus, it is suitable to foster a market-driven rollout.

4.5.4 *Complete Socialization of Costs*

The fourth design option of socializing the complete smart meter costs has several similarities with the previous design option, but goes beyond it in an important dimension. Obviously, as with the last option, the investment barrier for consumers is eliminated completely. The DSO is responsible for the smart meter investment costs and gets compensated through an increased fee for meter operation. Consumers, in return, have no upfront investment for a smart meter installation. Furthermore, even the increased operating costs are distributed over all consumers of the respective DSO. Consequently, consumers in this design option have no incentive to decide against an installation, as their decision does not directly lead to any increase in costs, in contrast to the two previous design options. This means a complete socialization of costs overcomes the chicken-egg problem and de facto leads to a comprehensive rollout of smart meters.³⁶

However, a major disadvantage of the de facto comprehensive rollout is the low cost-effectiveness. Every consumer is equipped with a

³⁴ The definition of the standard functionality can be regarded as a quality incentive defining an envisioned service level, which is a standard element of modern incentive regulation.

³⁵ For an overview of challenges in incentive regulation due to information asymmetries compare Joskow (2008a).

³⁶ The comprehensive rollout thus fulfills the EU 2020 rollout target described in the introduction. Thus it can be regarded as a further advantage for European countries.

smart meter independent of whether individual consumers benefit or not. Only extras above the standard meter defined by the regulatory regime are a result of the market mechanism. Furthermore, the regulatory regime needs to define the functionality of the standard smart meter and to set a cost limit for it, which can also have negative effects on the cost effectiveness as described above.

Since the complete socialization of costs leaves no “real” decision power to consumers, the degree of consumer education is rather low. Consumers are not encouraged to engage with the potential benefits of smart meters. As a consequence, it is reasonable to assume a lower rate and degree of adaption in behavior compared to the previous design options, resulting in lower gains of energy efficiency than possible. Thus, this approach inflates the cost base without yielding all the potential benefits.

Summing up, this design option is comparable to the Swedish approach to smart meter regulation. Although not stated explicitly, the regulatory guidelines result in a comprehensive rollout; with its disadvantages with respect to cost-effectiveness and consumer cooperation. Whether this design option can be classified as a market-driven rollout at all is questionable.

Comparing the four regulatory design options, a pattern emerges. Neither a total socialization of costs nor a complete lack of socialization is suitable to yield the benefits of a market-driven smart meter rollout. An intelligent regulation combines elements of a market-driven approach with incentives for investment. It offers incentives to invest through a socialization of costs and accounting for indirect network effects, but leaves the investment decision to the consumer. In deciding between socialization of operating costs and socialization of investment costs, the latter appears superior since it diminishes investment obstacles to the consumer more effectively and also allows for the pay-per-transaction logic of multi-sided market economics. Thereby, users of the [AMI](#) platform—retailers and consumers—do not pay for access to the platform; they only pay if they actually use the platform. However, it should be noted that the regulatory regime has to take on greater responsibility since it has to define a standard smart meter, which could result in lower cost effectiveness.

4.6 POLICY OUTLOOK

The analysis so far has demonstrated that the combined [AMI-DSO](#) is the market structure with the best characteristics to foster a market-driven rollout. Furthermore, the comparison of regulatory design options has revealed that socialization of investment costs exerts the advantages of a market-driven rollout best while providing high investment incentives. In this outlook three modifications are presented, which a regulator can apply to shift the balance between the advantages and

disadvantages of the above described market structure and design options.

In the previous sections, we assumed that costs are socialized evenly among all consumers of the respective DSO. An alternative to this approach is socialization according to individual electricity consumption in Kilowatt hour (kWh). A consumer with higher than average electricity consumption would then pay a larger portion of the costs to be socialized, whereas a consumer with a lower than average electricity consumption would pay a lower portion. Thus, the incentives to opt for a smart meter in order to participate in the benefits are lower for low-consumption consumers and higher for high-consumption consumers. At first glance, this uneven cost split may seem unfair. However, a consumer with higher electricity consumption has a larger potential to benefit from installing a smart meter.³⁷ Thus, by applying a socialization of costs according to energy consumption, incentives are adjusted with respect to potential benefits from the smart meter installation. This modification of socialized costs thereby allows the regulator to gauge incentives according to the potential impact of consumers on energy efficiency.

The second possible modification concerns the competitive environment of the DSO. In the described market structure of the combined AMI-DSO in section 4.4, there is no competition with respect to the AMI infrastructure. A soft form of competition, however, would be possible by allowing DSOs to install and operate smart meters in regions where they do not own the distribution grid.³⁸ Thereby, the regulator can trade off advantages of the different market structures against each other. The competition would create a certain degree of cost pressure, encouraging DSOs to operate the AMI platform efficiently and to strive for innovations. The downside of this modification would be that the investment security for DSOs would be reduced. Consumers could change the meter operator, which would leave the DSO with stranded assets. More importantly, the trade-off would also affect the possibility for socialization. If an increase in fees for meter operation is too great due to socialization, consumers would have the power to mandate a DSO from another area with the operation of the (smart) meter.

The last modification involves a time component. Depending on the degree of the smart meter rollout, the ranking order of the market structure's characteristics can change. A characteristic such as socialization of smart meter costs, which affects the possibility of a market structure to address the investment barrier for consumers, is more

³⁷ This builds on a constant savings factor for the implementation of the smart meter, e.g. $x\%$ savings per consumer. Calculations of consumers' savings potential frequently apply this type of constant savings factor (see *Frontier Economics*, 2007).

³⁸ This form of competition is only meaningful if the data transfer from the smart meter to the data center takes place via radio-based or independent Internet Protocol (IP)-based wire bound communication technology. In case the data transfer requires powerline communication, true competition would probably not develop.

meaningful in the early stages of the rollout. Once a bulk of consumers is equipped with a smart meter, this characteristic could be neglected. In contrast, incentives for operating efficiency and innovation become more important the more smart meters are in place. A regulator that regards this shift in ranking order as relevant could switch from one market structure to another. For example, the regulatory frame could start with a combined [AMI-DSO](#) for the rollout period and announce upfront that after a specified period the market would be open to competition to leverage the advantages of the independent [AMI](#) operator market structure.

A general recommendation on which modifications to carry out is not meaningful as the decision depends highly on the current market structure and, above all, on the goals of the regulatory authority.

4.7 CONCLUSION

The electricity market is a complex network of multiple stakeholders performing different functions. The fact that grid operators manage a natural monopoly further adds to the complexity. Smart meters are expected to increase the overall efficiency of this market, but respective benefits do not outweigh costs for every consumer. As a consequence, several countries try to pursue a market-driven rollout and thus let the market decide on a smart meter's usefulness in each distinct case. However, because the infrastructure provider has to be regulated, there is a definite need for some form of regulatory intervention. In this paper we argue that regulators should realize that smart meters, in contrast to conventional Ferraris meters, introduce a multi-sided market. Therefore, they have to deal with the corresponding peculiarities with respect to the price structure in such markets.

The market structure that is best suited to deal with these peculiar features places the responsibility for installing and operating smart meters on the [DSO](#). The combined [AMI-DSO](#) can capture all network effects—either through the operation of the [AMI](#) or through competition in the retail market. Furthermore, it can provide strong investment incentives to solve the chicken-egg problem. This is achieved mainly through a socialization of costs related to the rollout—if the regulator allows it. The justification for a socialization of costs is primarily based on the fact that some positive externalities such as improvements in quality accrue to all consumers. We argue that the smart meter investment costs should be socialized, while the operating costs should remain with individual consumers, as this reflects the pay-per-transaction logic to internalize indirect network effects and also exerts the benefits of a market-driven smart meter rollout.

However, our market structure analysis also covers aspects such as operating efficiency or incentives for innovation. The combined [AMI-DSO](#)—as a regulated monopolist—does not perform as well in

these categories. Consequently, a regulator may choose to enact hybrid forms of the pure market structures we discuss or open up the market for more competition after some time when the emphasis shifts from facilitating smart meter diffusion to operating efficiency or innovation. Summing up, the optimal regulation of the smart meter rollout depends on the preferences of the regulator. If the regulatory focus is on a market-driven rollout—to achieve cost effectiveness as well as energy efficiency through strong consumer cooperation—the insights of this paper are highly relevant.

Part IV

REFLECTION

DISCUSSION AND CONCLUSION

This thesis has tackled certain important questions related to multi-sided market economics. The first part provided a pronouncement of the importance of this theory, its relevance in many important markets, and an overview of the work conducted in the field so far with a strong focus on payment card economics. The second part pondered with two theoretical models the question, why merchants in different sectors have to pay different merchant usage fees to payment card networks. The third part then applied the theory of multi-sided markets to the energy sector, where important lessons for the regulation of a smart meter rollout could be derived.

Scholars first recognized the peculiar features of multi-sided markets when discussing issues related to antitrust cases involving payment card networks. To this day, the market for payment cards remains the best researched multi-sided market. Card networks facilitate the downstream market exchange of goods and services by supplying a means of financial intermediation. In doing so, they perform an indispensable function for all economic markets providing the grease for the economic engine. However, payment card networks are accused of exploiting their role and excessively 'tax' market participants because they are deemed indispensable. Still, their pricing strategies are not necessarily influenced by the fact that card networks have market power and face little competition. They are rather a result of the peculiarities of multi-sided markets and may thus even be a result of competition. The more consumers use a particular payment card, the larger its value becomes to the participating merchants. Therefore, card networks have leverage over merchants if they obtain the patronage of card users. This is why consumers often even receive benefits for card usage rather than having to pay for the service. The result—it is feared—is that there are too many card transactions, too much output, rather than too little, as is the standard concern about exploiting market power. However, competition among card networks could even exacerbate this result rather than ameliorate it.

Whereas the apparent price structure for payment cards has been intensively debated and explained, the fact that merchant usage fees vary significantly among merchant sectors has attracted less scrutiny. The second part of this thesis has tried to shed light on this particular pricing decision in the payment card market. Two theoretical models are presented to investigate this observation for two scenarios: Merchants engaging in Bertrand price competition and merchants in Cournot quantity competition. From the perspective of introductory

level microeconomics, these two modes of competition have vastly differing outcomes. While a duopoly engaging in quantity competition earns economic rents through asking prices above the perfectly competitive market price, price competition in its simplest form leads to competitive pricing without economic rents. The microeconomic literature has developed two explanations, which avoid this last, often deemed unrealistic, result for Bertrand competition: Introducing either capacity constraints in production or allowing for product differentiation. Both prevent one company from serving the whole market with a lower price and thus allow for economic rents. In this thesis, the Bertrand case is modeled using product differentiation, which is more prevalent in some merchant sectors than in others.

In both the Bertrand as well as the Cournot model in chapters 2 and 3, respectively, a unitary payment card network imposes its profit-maximizing merchant usage fee on all payment card transactions. The simplification of a unitary network rather than a more complex multi-party network facilitates a focus on the primary object of investigation, namely defining characteristics in the downstream market. This assumption is deemed neither to influence the price structure nor the overall objective function of the card network. The main results of both approaches are reinforcing and add nuance. The merchant usage fee is imposed as a 'tax' on the merchants' rents and thus decreases in the price elasticity of demand. A related idea is the substitutability of products. If products are easily substitutable, consumers can more easily switch to alternatives if merchants increase prices. The Bertrand model, which explicitly tests for substitutability, finds that it thus decreases merchant usage fees.

Furthermore, the Bertrand model finds that the merchant usage fee is increasing in the overall size of the market. In reality, this increase might be somewhat outweighed by the influence of a higher bargaining power of larger merchants, that is, if a larger market size translates to larger merchant size. But the theoretical model ignores the effect of bargaining power, as a higher bargaining power is reported to have only negligible effects in the United States according to the [United States Government Accountability Office \(2009\)](#). Lastly, there is a relation between the fraction of consumers who are preferring card payments and the merchant usage fee. There are two effects at work here if the fraction of card users increases. First, merchants are able to sell more and increase revenues. Second, merchants have to pay the merchant usage fee for a higher fraction of their sales, and thus their overall costs increase. In the Bertrand model, the second effect always outweighs the first for the interior solution, so that the merchant usage fee is decreasing in the fraction of cardholders. In the Cournot model, these two countervailing effects lead to an inverse V-curve. If there are only a few cardholders, the first effect is stronger, and fee levels increase. That is, merchants are willing to accept higher

fee levels. However, at a certain point the second effect outweighs the first, and card networks self-restrict the merchant usage fees.

Still, differences in merchant usage fees may also be influenced by the marketing efforts of payment card networks. As a variation of the Bertrand model shows, they have an incentive to skew card usage toward sectors with low price elasticity of demand, where merchant usage fees are higher. Because of the inverse V-curve relationship between fees and the fraction of cardholders, this practice may have ambiguous results. It can either widen (in a state with few cardholders) or shorten (with many cardholders) the spread among the sectoral fee levels.

Overall, there is a convincing economic rationale behind sectoral differences in fee levels. The basic payment function is provided for the whole economy. Nevertheless, profit maximization leads card networks to engage in a double marginalization of consumers. On these grounds, a regulation of fees may be justified. The Durbin Amendment of the Dodd-Frank Act has just enacted a unified fee for all debit card transactions in the [US](#) ([Bernard & Protess, 2011](#)). While it definitely limits banks' profits gained from offering debit card services, its competitive effects will still have to be observed. If the Australian experience is any indication, consumers could easily switch to competing payment instruments ([Chang et al., 2005](#)).

A natural next step in the effort to understand price discrimination between sectors would be to test the predictions of these two theoretical models empirically. Such an analysis would necessitate aggregate information on the different types of merchant sectors, such as market size, price elasticities of demand, product substitutability, and fraction of card payments. Then, a regression should be run to test whether the influence of these variables on the merchant usage fee data the [EU](#) compiled corresponds to the predictions in the theoretical models.

An extension of the theoretical models could also look at competitive environments, where two or more networks compete for the patronage of consumers and merchants. Both models so far assume a monopolistic unitary card network. A competitive environment should somewhat reduce the bargaining power of the network so that it might not be able to ask the highest acceptable merchant usage fee. On the other hand, competition between card networks for the patronage of consumers would increase so that the price structure may not be affected at all. It is thus unclear whether merchants actually benefit from increased competition. It could rather force the card network to share a larger fraction of its profits with consumers, who now have a choice between payment cards, so that the harmful effects of double marginalization could be mitigated. The thesis at hand leaves these extensions for future research.

The third part of this thesis takes the insights from multi-sided market economics and applies them to a field that has thus far not been

recognized as multi-sided: The market for smart electricity meters. As Wright (2004a) has noted, not being aware of the multi-sidedness of a market can lead to significant regulatory misjudgments. The analysis in chapter 4 makes the case that this is true for market-driven rollouts of smart meters for households in liberalized electricity markets, such as Germany. Based on the implications of the multi-sided market literature, it concludes that a combined smart meter and grid operator, with a regulatory setup that permits the socialization of smart meter investment costs among all electricity consumers, is best suited for implementing a market-driven smart meter rollout.

The complexities of the electricity industry are manifold. Historically, energy companies have been treated as national champions and been integrated along the value chain. Only the last few decades have seen efforts to disentangle these large corporations and liberalize the market. Further, the infrastructure provider—for this purpose, the DSO—manages a natural monopoly. This means that regulatory oversight is essential to ensure low prices and innovation. Around the world, countries and states have tried various approaches to securing a low-cost reliable electricity supply. With the advent of renewable energy sources and the desire to increase the efficiency of energy consumption, efforts are being made to increase the flexibility and reliability of the electricity grid. Smart meters are an essential part of this effort.

In contrast to conventional electricity meters, smart meters record and communicate consumption in real time, allowing for a variety of new services and applications, such as variable tariffs, depending on the time of use. Prior experience with their introduction has been mixed, so some countries want to rely on market forces rather than making their use mandatory. However, adoption rates have, as a result, been insignificant in the household sector. For many consumers, the costs outweigh the immediate benefits, and they do not take into account the positive externalities resulting from additional features of smart meters.

The analysis in chapter 4 is based on the recognition that the smart meter market is multi-sided. The smart meter platform serves as a shared resource for at least two distinct customer groups, where the value of the platform for one side increases with the number of household consumers who use it. It is thus essential to get enough consumers on board to make the platform valuable for the other market side. This chicken-egg problem suggests that the other market side should take on some of the cost burden that consumers face, so as to induce them to invest in smart meters. Because of the regulation of the infrastructure provider, this outcome has so far not been achieved. Furthermore, to internalize the positive externalities it can be argued that consumers with conventional Ferraris meters should share in the cost burden to some degree.

In analyzing all theoretically feasible market structures, the grid operator is identified as the best suited smart meter operator to achieve a market-driven rollout because this market structure incorporates the characteristics of multi-sided markets. The chicken-egg problem is approached through high investment security and socialization of costs. This socialization would best tackle the one-off investment costs rather than the operating costs of the smart meter to only reduce the investment hurdle. Furthermore, an optimal price structure that accounts for indirect network effects does provide investment incentives.

Since the smart meter market has thus far not been investigated from a multi-sided market perspective, the existing literature focuses either exclusively on smart meters or on multi-sided markets. Consequently, the analysis provides a completely new approach to smart meter regulation. While there are countries, in which incentives to individual market participants are strong enough to invest in an [AMI](#) infrastructure rendering further regulation unnecessary, other countries experience that the fragmentation of benefits along the value chain in a liberalized electricity market inhibits investments in smart meters in the household sector. These latter countries either have the choice between a mandated rollout, a market-driven rollout, or no significant rollout at all. Supposing that they favor a market-driven rollout, the application of the multi-sided market literature then yields direct regulatory recommendations. The grid operator rather than other market participants should be in charge of the rollout. The investment costs for a standard smart meter should be socialized over all consumers, and the operating costs should be charged as part of the individual electricity bill. Everything else can be left to market forces.

Part V

APPENDIX

MATHEMATICAL PROOFS

A.1 APPENDIX CHAPTER 2

Proof of Lemma 2.2

The f.o.c. of the profit function is

$$\frac{\partial \pi_1}{\partial p_1} = (A - 2Bp_1 + \tau p_2)(1 - \gamma a) + Bc \stackrel{!}{=} 0$$

Because of symmetry of merchants we know they will set the same price $p = p_1 = p_2$. Solving for p gives the result. Inserting p^* into the demand function then leads to q^* and by symmetry we have $Q^* = 2q^*$.

Proof of Proposition 2.1

$$\text{First Statement: } \frac{\partial a^*}{\partial A} = -\frac{\frac{\partial^2 \Pi}{\partial A \partial a}}{\frac{\partial^2 \Pi}{\partial a^2}} > 0$$

The denominator is a s.o.c. of a maximization problem and thus always negative. It therefore suffices to find $\frac{\partial^2 \Pi}{\partial A \partial a} > 0$. We have

$$\begin{aligned} \frac{\partial^2 \Pi}{\partial A \partial a} &= \left[\frac{\partial \sigma}{\partial A} + \frac{\frac{\partial \phi}{\partial A}}{1 - \gamma a} - \frac{\frac{\partial \xi}{\partial A}}{(1 - \gamma a)^2} \right] \gamma \\ &\quad + \left[\frac{\gamma \frac{\partial \phi}{\partial A}}{(1 - \gamma a)^2} - \frac{2\gamma \frac{\partial \xi}{\partial A}}{(1 - \gamma a)^3} \right] \gamma a \end{aligned} \quad (\text{A.1})$$

and as $\frac{\partial \sigma}{\partial A} = \frac{4AB}{(2B - \tau)^2} > 0$, $\frac{\partial \phi}{\partial A} = \frac{2B\tau c}{(2B - \tau)^2} > 0$, and $\frac{\partial \xi}{\partial A} = 0$ the statement follows.

$$\text{Second Statement: } \frac{\partial a^*}{\partial B} = -\frac{\frac{\partial^2 \Pi}{\partial B \partial a}}{\frac{\partial^2 \Pi}{\partial a^2}} < 0$$

Again, it is enough to find $\frac{\partial^2 \Pi}{\partial B \partial a}$. This gives

$$\begin{aligned} \frac{\partial^2 \Pi}{\partial B \partial a} &= \left[\frac{\partial \sigma}{\partial B} + \frac{\frac{\partial \phi}{\partial B}}{1 - \gamma a} - \frac{\frac{\partial \xi}{\partial B}}{(1 - \gamma a)^2} \right] \gamma \\ &\quad + \left[\frac{\gamma \frac{\partial \phi}{\partial B}}{(1 - \gamma a)^2} - \frac{2\gamma \frac{\partial \xi}{\partial B}}{(1 - \gamma a)^3} \right] \gamma a \end{aligned} \quad (\text{A.2})$$

which is negative as $\frac{\partial \sigma}{\partial B} = -\frac{2\tau A^2}{(2B - \tau)^3} < 0$, $\frac{\partial \phi}{\partial B} = 2A\tau c \frac{-\tau - 2B}{(2B - \tau)^3} < 0$, and $\frac{\partial \xi}{\partial B} = \frac{2Bc^2}{(2B - \tau)^3} (\tau^2 + 2B^2 - 3B\tau) > 0$.

Third Statement: $\frac{\partial a^*}{\partial \tau} = -\frac{\frac{\partial^2 \Pi}{\partial \tau \partial a}}{\frac{\partial^2 \Pi}{\partial a^2}} > 0$

This is given by

$$\frac{\partial^2 \Pi}{\partial \tau \partial a} = \left[\frac{\partial \sigma}{\partial \tau} + \frac{\frac{\partial \phi}{\partial \tau}}{1 - \gamma a} - \frac{\frac{\partial \xi}{\partial \tau}}{(1 - \gamma a)^2} \right] \gamma + \left[\frac{\gamma \frac{\partial \phi}{\partial \tau}}{(1 - \gamma a)^2} - \frac{2\gamma \frac{\partial \xi}{\partial \tau}}{(1 - \gamma a)^3} \right] \gamma a > 0 \quad (\text{A.3})$$

because we have $\frac{\partial \sigma}{\partial \tau} = \frac{4A^2B}{(2B-\tau)^3} > 0$, $\frac{\partial \phi}{\partial \tau} = \frac{2ABc}{(2B-\tau)^2} + \frac{4ABc\tau}{(2B-\tau)^3} > 0$, and $\frac{\partial \xi}{\partial \tau} = -\frac{2B^2\tau c^2}{(2B-\tau)^3} < 0$.

Fourth Statement: $\frac{\partial a^*}{\partial \gamma} < 0$

The derivative w.r.t. γ gives

$$\begin{aligned} \frac{\partial^2 \Pi}{\partial \gamma \partial a} = & \left[\sigma + \frac{\phi}{1 - \gamma a} - \frac{\xi}{(1 - \gamma a)^2} \right] \gamma + \left[\frac{a\phi}{(1 - \gamma a)^2} - \frac{2a\xi}{(1 - \gamma a)^3} \right] \gamma + \\ & \left[\frac{\gamma\phi}{(1 - \gamma a)^2} - \frac{2\gamma\xi}{(1 - \gamma a)^3} \right] a + \left[\frac{\phi(1 + \gamma a)}{(1 - \gamma a)^3} - \frac{2\xi(1 + 2\gamma a)}{(1 - \gamma a)^4} \right] \gamma a \end{aligned} \quad (\text{A.4})$$

Denote the different parts of the sum as *I*, *II*, *III*, *IV* from left to right. Note for *I*: $\left[\sigma + \frac{\phi}{1 - \gamma a} - \frac{\xi}{(1 - \gamma a)^2} \right] \gamma = \frac{\Pi}{a\gamma}$. Then we find that *I* + *III* gives

$$\left[\sigma + \frac{\phi}{1 - \gamma a} - \frac{\xi}{(1 - \gamma a)^2} \right] \gamma + \left[\frac{\gamma\phi}{(1 - \gamma a)^2} - \frac{2\gamma\xi}{(1 - \gamma a)^3} \right] a = \frac{\partial \Pi}{\partial a} \frac{1}{\gamma} \quad (\text{A.5})$$

If the payment network is setting the optimal merchant usage fee (in other words if we have $\frac{\partial \Pi}{\partial a} = 0$) then in A.5 *I* + *III* = 0. So the sign of $\frac{\partial^2 \Pi}{\partial \gamma \partial a}$ is determined by *II* + *IV*

$$\left[\frac{a\phi}{(1 - \gamma a)^2} - \frac{2a\xi}{(1 - \gamma a)^3} \right] \gamma + \left[\frac{\phi(1 + \gamma a)}{(1 - \gamma a)^3} - \frac{2\xi(1 + 2\gamma a)}{(1 - \gamma a)^4} \right] \gamma a < 0 \quad (\text{A.6})$$

This has to be negative because *I* > *II*

$$\left[\sigma + \frac{\phi}{1 - \gamma a} - \frac{\xi}{(1 - \gamma a)^2} \right] \gamma > \left[\frac{\phi}{(1 - \gamma a)^2} - \frac{2\xi}{(1 - \gamma a)^3} \right] \gamma a \quad (\text{A.7})$$

And *III* > *IV*

$$\left[\frac{\phi}{(1 - \gamma a)^2} - \frac{2\xi}{(1 - \gamma a)^3} \right] \gamma a > \left[\frac{\phi(1 + \gamma a)}{(1 - \gamma a)^3} - \frac{2\xi(1 + 2\gamma a)}{(1 - \gamma a)^4} \right] \gamma a \quad (\text{A.8})$$

So we have *I* + *III* = 0, and *II* < *I*, as well as *IV* < *III*. Consequently, the full term *I* + *II* + *III* + *IV* has to be negative: $\frac{\partial^2 \Pi}{\partial \gamma \partial a} < 0$. This directly yields the claim.

Proof of Proposition 2.2

Taking the derivative of the price elasticity of demand (2.3) w.r.t. A we find

$$\frac{\delta \epsilon}{\delta A} = -\frac{p_1 B_1}{[A - B_1 p_1 + \tau p_2]^2} < 0 \quad (\text{A.9})$$

Because we know that $\frac{\delta a^*}{\delta A} > 0$, these two relations reveal that $\frac{\delta a^*}{\delta \epsilon} < 0$.

Proof of Proposition 2.3

The inverse demand function can be re-written in the alternative formulation as

$$q_1 = \frac{(\alpha - p_1) \beta - (\alpha - p_2) \theta}{\beta^2 - \theta^2} \quad (\text{A.10})$$

From this we can derive the alternative price elasticity of demand

$$\epsilon_{q_1, p_1} = \left| -\frac{p_1 \beta}{(\alpha - p_1) \beta - (\alpha - p_2) \theta} \right| \quad (\text{A.11})$$

The derivative w.r.t. θ gives

$$\frac{\partial \epsilon}{\partial \theta} = \frac{p_1 \beta (\alpha - p_2)}{[(\alpha - p_1) \beta - (\alpha - p_2) \theta]^2} > 0 \quad (\text{A.12})$$

And because we know that $\frac{\partial a^*}{\partial \epsilon} < 0$, we find that in such a case that

$$\frac{\partial a^*}{\partial \theta} < 0 \quad (\text{A.13})$$

proving the statement.

A.2 APPENDIX CHAPTER 3

Proof for the Concavity of the Merchant's Profit Function

Concavity of the merchant profit requires

$$\begin{aligned}\frac{\partial \pi}{\partial q_n} &= \left(1 - \frac{1}{\varepsilon N}\right) (q_n + q_{-n})^{-\frac{1}{\varepsilon}} (1 - \gamma a) - k = 0 \\ \frac{\partial^2 \pi}{\partial q_n^2} &= -\frac{1}{\varepsilon} \left(1 - \frac{1}{\varepsilon N}\right) (q_n + q_{-n})^{-\frac{1}{\varepsilon}-1} (1 - \gamma a) < 0\end{aligned}$$

as long as $1 - \frac{1}{\varepsilon N} > 0$ which means $\varepsilon > \frac{1}{N}$.

Deriving the Highest Acceptable Merchant Usage Fee

The threshold can be found by setting the profits of both scenarios equal

$$(1 - \gamma) q_n^{nc} (p^{nc} - k) = q_n^* p^* (1 - \gamma a) - q_n^* k$$

Inserting the derived equilibrium values gives

$$\begin{aligned}(1 - \gamma) \frac{1}{N} \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^\varepsilon \left(\frac{k}{1 - \frac{1}{\varepsilon N}} - k\right) &= \frac{1}{N} \left(\frac{(1 - \frac{1}{\varepsilon N})(1 - \gamma a)}{k}\right)^\varepsilon \frac{k(1 - \gamma a)}{(1 - \frac{1}{\varepsilon N})(1 - \gamma a)} \\ &\quad - \frac{1}{N} \left(\frac{(1 - \frac{1}{\varepsilon N})(1 - \gamma a)}{k}\right)^\varepsilon k\end{aligned}$$

The right hand side can be aggregated to

$$(1 - \gamma) \frac{1}{N} \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^\varepsilon \left(\frac{k}{1 - \frac{1}{\varepsilon N}} - k\right) = \frac{1}{N} \left(\frac{(1 - \frac{1}{\varepsilon N})(1 - \gamma a)}{k}\right)^\varepsilon \left(\frac{k}{(1 - \frac{1}{\varepsilon N})} - k\right)$$

Factorizing common parts simplifies the expression to

$$(1 - \gamma) = (1 - \gamma a)^\varepsilon$$

Solving for a yields the result

$$\bar{a} = \frac{1 - (1 - \gamma)^\frac{1}{\varepsilon}}{\gamma}$$

Proof for Lemma 1

The highest acceptable merchant usage fee can be rewritten as

$$\bar{a} = \frac{1}{\gamma} - \frac{1}{\gamma} e^{\frac{1}{\varepsilon} \ln(1 - \gamma)}$$

The derivative with respect to the price elasticity

$$\frac{\partial \bar{a}}{\partial \varepsilon} = \frac{(1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma \varepsilon^2} \ln(1 - \gamma) < 0$$

is negative because $0 < \gamma \leq 1$. With respect to γ gives

$$\frac{\partial \bar{a}}{\partial \gamma} = \frac{\frac{\gamma}{\varepsilon} (1 - \gamma)^{\frac{1}{\varepsilon} - 1} - 1 + (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma^2}$$

which can either be positive (for elastic demands) or negative (for inelastic demands) and for $\varepsilon = 1$ it gives

$$\frac{\partial \bar{a}}{\partial \gamma} = \frac{\gamma - 1 + 1 - \gamma}{\gamma^2} = 0$$

Maximization of Card Network' Profits (Standard Model)

Deriving the Profit Maximum

Deriving the maximization problem (3.12) with respect to the merchant usage fee

$$\begin{aligned} \frac{\partial \Omega}{\partial a} = & \gamma \left(\frac{(1 - \frac{1}{\varepsilon N})}{k} \right)^{\varepsilon - 1} (1 - \gamma a)^{\varepsilon - 1} \\ & - \gamma^2 a (\varepsilon - 1) \left(\frac{(1 - \frac{1}{\varepsilon N})}{k} \right)^{\varepsilon - 1} (1 - \gamma a)^{\varepsilon - 2} = 0 \end{aligned}$$

Canceling terms brings

$$1 = \frac{\gamma a (\varepsilon - 1)}{1 - \gamma a}$$

And solving for a gives the result

$$a^* = \frac{1}{\gamma \varepsilon}$$

At this merchant usage fee the profit maximum is obtained.

Threshold Between Highest Acceptable Merchant Usage Fee and Profit Maximum

The threshold between the interior profit maximum and the highest acceptable merchant usage fee can then be determined by setting the two terms equal

$$\frac{1}{\gamma \varepsilon} = \frac{1 - (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma}$$

Canceling common terms

$$\frac{1}{\varepsilon} = 1 - (1 - \gamma)^{\frac{1}{\varepsilon}}$$

Brining γ to one side

$$(1 - \gamma)^{\frac{1}{\varepsilon}} = 1 - \frac{1}{\varepsilon}$$

And solving

$$\hat{\gamma} = 1 - \left(1 - \frac{1}{\varepsilon}\right)^{\varepsilon}$$

Alternative Solution: Maximization with a Constraint

In the case where the maximization problem (3.12) includes the constraint of not being larger than the highest acceptable merchant usage fee, it becomes

$$\Omega = \max_a \gamma a \left(\frac{(1 - \frac{1}{\varepsilon N})}{k} \right)^{\varepsilon-1} (1 - \gamma a)^{\varepsilon-1} - \lambda \left(a - \frac{1 - (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma} \right)$$

Deriving it with respect to the merchant usage fee gives

$$\begin{aligned} \frac{\partial \Omega}{\partial a} = & \gamma \left(\frac{(1 - \frac{1}{\varepsilon N})}{k} \right)^{\varepsilon-1} (1 - \gamma a)^{\varepsilon-1} \\ & - \gamma^2 a (\varepsilon - 1) \left(\frac{(1 - \frac{1}{\varepsilon N})}{k} \right)^{\varepsilon-1} (1 - \gamma a)^{\varepsilon-2} - \lambda = 0 \end{aligned}$$

Factorizing the common parts

$$\lambda = \gamma \left(\frac{(1 - \frac{1}{\varepsilon N}) (1 - \gamma a)}{k} \right)^{\varepsilon-1} \left(1 - \frac{\gamma a (\varepsilon - 1)}{1 - \gamma a} \right)$$

And simplifying the last expression gives

$$\lambda = \gamma \left(\frac{(1 - \frac{1}{\varepsilon N}) (1 - \gamma a)}{k} \right)^{\varepsilon-1} \frac{1 - \gamma a \varepsilon}{1 - \gamma a}$$

Inserting the constraint $a = \frac{1 - (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma}$ yields

$$\lambda = \gamma \left(\frac{(1 - \frac{1}{\varepsilon N}) \left(1 - \gamma^{\frac{1 - (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma}} \right)}{k} \right)^{\varepsilon-1} \frac{1 - \gamma^{\frac{1 - (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma}} \varepsilon}{1 - \gamma^{\frac{1 - (1 - \gamma)^{\frac{1}{\varepsilon}}}{\gamma}}}$$

Canceling terms simplifies the expression to

$$\lambda = \gamma \left(\frac{\left(1 - \frac{1}{\varepsilon N}\right) \left(1 - 1 + (1 - \gamma)^{\frac{1}{\varepsilon}}\right)}{k} \right)^{\varepsilon-1} \frac{1 - \varepsilon \left(1 - (1 - \gamma)^{\frac{1}{\varepsilon}}\right)}{1 - 1 + (1 - \gamma)^{\frac{1}{\varepsilon}}}$$

Rearranging then yields the solution

$$\lambda = \gamma \left(\frac{\left(1 - \frac{1}{\varepsilon N}\right)}{k} \right)^{\varepsilon-1} (1 - \gamma)^{1 - \frac{1}{\varepsilon}} \left(\frac{1 - \varepsilon}{(1 - \gamma)^{\frac{1}{\varepsilon}}} + \varepsilon \right)$$

where the constraint (maximum a that merchants are willing to accept) is binding for $\lambda > 0$ while it is not binding for $\lambda = 0$. The factor γ is always positive as well as the first parenthesis. The second parenthesis turns negative if $\varepsilon \leq \frac{1}{N}$, which is ruled out for concavity of the merchant's profit maximization. As a result, $\lambda = 0$ can only occur if the last parenthesis is zero, which is the case for $\gamma = 1 - \left(1 - \frac{1}{\varepsilon}\right)^{\varepsilon}$. This means, for $\gamma < 1 - \left(1 - \frac{1}{\varepsilon}\right)^{\varepsilon}$ and $\varepsilon > \frac{1}{N}$ the constraint is binding and $a = \bar{a}$. In other words, the card network will set the highest acceptable merchant usage fee if price elasticity of demand is large enough and the fraction of cardholders does not exceed a certain value. For instance, for unit elasticity, the card network sets the highest merchant usage fee if $\gamma < 1$, while for $\varepsilon \rightarrow \infty^+$, $\gamma \rightarrow 0$ and the network solves for an interior maximum. For that case where the constraint is non-binding, the solution has already been obtained.

Maximization of Card Network' Profits (Model Variation)

Proof of derivative in model variation

$$\Omega = \max_{a,s} s\gamma (ap^*(a) - c(s)) Q^*(a) \quad \text{s.t. } a = \frac{1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}}{s\gamma}$$

Inserting of the equilibrium price and quantity and rearranging brings

$$\Omega = \max_{a,s} s\gamma a \left(\frac{\left(1 - \frac{1}{\varepsilon N}\right) (1 - s\gamma a)}{k} \right)^{\varepsilon-1} - s\gamma c(s) \left(\frac{\left(1 - \frac{1}{\varepsilon N}\right) (1 - s\gamma a)}{k} \right)^{\varepsilon}$$

Inserting the constraint gives

$$\begin{aligned} \Omega = \max_s s\gamma \frac{1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}}{s\gamma} & \left(\frac{\left(1 - \frac{1}{\varepsilon N}\right) \left(1 - s\gamma^{\frac{1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}}{s\gamma}}\right)}{k} \right)^{\varepsilon-1} \\ & - s\gamma c(s) \left(\frac{\left(1 - \frac{1}{\varepsilon N}\right) \left(1 - s\gamma^{\frac{1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}}{s\gamma}}\right)}{k} \right)^{\varepsilon} \end{aligned}$$

Canceling terms and simplifying yields

$$\Omega = \max_s \left(1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}\right) (1 - s\gamma)^{1 - \frac{1}{\varepsilon}} \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^{\varepsilon - 1} - s\gamma c(s) (1 - s\gamma) \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^{\varepsilon}$$

Deriving the function with respect to the propensity to use cards s and setting it equal to zero $\frac{\partial \Omega}{\partial s} = 0$ yields

$$\begin{aligned} 0 = & \frac{\gamma (1 - s\gamma)^{\frac{1}{\varepsilon} - 1}}{\varepsilon (1 - s\gamma)^{\frac{1}{\varepsilon} - 1}} \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^{\varepsilon - 1} - \left(1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}\right) \left(1 - \frac{1}{\varepsilon}\right) \gamma (1 - s\gamma)^{-\frac{1}{\varepsilon}} \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^{\varepsilon - 1} \\ & - \gamma c(s) (1 - s\gamma) \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^{\varepsilon} - s\gamma c'(1 - s\gamma) \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^{\varepsilon} + s\gamma^2 c(s) \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right)^{\varepsilon} \end{aligned}$$

Canceling terms simplifies the expression to

$$\begin{aligned} 0 = & \frac{1}{\varepsilon} - \left(1 - (1 - s\gamma)^{\frac{1}{\varepsilon}}\right) \left(1 - \frac{1}{\varepsilon}\right) (1 - s\gamma)^{-\frac{1}{\varepsilon}} \\ & + \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right) (-c(s) (1 - s\gamma) - sc'(1 - s\gamma) + s\gamma c(s)) \end{aligned}$$

Further rearranging yields the final result

$$0 = 1 - \left(1 - \frac{1}{\varepsilon}\right) (1 - s\gamma)^{-\frac{1}{\varepsilon}} - \left(\frac{1 - \frac{1}{\varepsilon N}}{k}\right) ((1 - 2s\gamma) c(s) + sc'(1 - s\gamma))$$

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COLOPHON

This thesis was written in L^AT_EX and typeset with L^AT_EX 2_ε using Hermann Zapf's *Palatino* and *Euler* type faces (Type 1 PostScript fonts *URW Palladio L* and *FPL* were used). The listings are typeset in *Bera Mono*, originally developed by Bitstream, Inc. as “Bitstream Vera”. (Type 1 PostScript fonts were made available by Malte Rosenau and Ulrich Dirr.)

The typographic style was inspired by [Bringhurst](#)'s genius as presented in *The Elements of Typographic Style* ([Bringhurst, 2002](#)). It is available for L^AT_EX via CTAN as “[classicthesis](#)”.

Final Version as of November 21, 2011 at 23:24.

DECLARATION

I declare on my word of honor that I am the sole author of this thesis. The exceptions to this are the sections for which one or more co-authors were involved; these sections are explicitly identified and the names of the co-authors are completely and truthfully listed. I confirm that I made a significant contribution to the sections for which one or more co-authors were involved that justifies my own co-authorship. The work was completed using only the cited sources. All information taken directly from source material or ideas based on information taken from source material have been clearly identified through the cited references.

Essen, 21. November 2011

Jens Uhlenbrock