Chapter 1

Introduction

This thesis deals with various aspects of market behavior in deregulated energy markets. In the last thirty years, the energy sector has been among those industries that have undergone a worldwide deregulation process with the aim to enhance overall market performance. This process started in the Anglo-Saxon world under the Thatcher government in the U.K. and the Carter and Reagan regimes in the U.S. and, often using the U.K. and U.S. liberalization policies as blueprints, many countries followed suit. Next to the energy sector, other industries that have been privatized include transportation, postal services, health care and telecommunications (see e.g. Armstrong and Sappington, 2006).

Economic theory has proved to be a useful guidance in developing reform policies that create well-functioning markets. First of all, the theory of incentive regulation delivers valuable tools if natural monopolies in one or more market segments remain. This is particularly true for most of the sectors that have been liberalized, as these industries exhibit significant economies of scale in the provision of infrastructure services. This makes it socially undesirable to duplicate physical networks and as a result, a monopolistic firm, under control of a regulator, owns the infrastructure assets. Insights from the research on incentive regulation can be applied by the regulator to entice the monopolistic network owner to improve upon its own performance and, given the monopolist’s pivotal position in the industry, to ameliorate the func-

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1Numerous studies in this area have not only aimed at characterizing the main determinants of successful deregulation, but have also attempted to predict the qualitative and quantitative effects of restructuring industries. Winston (1993), providing an interesting overview of research on various U.S. sectors that have been liberalized, assesses that economists’ predictions about the effects of deregulation are by and large accurate.
tioning of other layers of the value chain at the same time. This theory recognizes that the regulated firm has an informational advantage over the regulator, which implies that the optimal regulatory policy leaves some rent to the firm in order to bring the firm’s incentives more in line with the regulator’s objective.\footnote{We refer to Laffont and Tirole (1993) and Armstrong and Sappington (2007) for exhaustive discussions on the complexities of designing regulatory policy when a monopoly seller is better informed than the regulator about demand conditions or the cost of production.}

In parts of the industries where markets have been created, like wholesale and retail segments, research in the field of industrial organization (IO) provides us with useful insights into optimal market design. Focusing on strategic behavior of firms in imperfectly competitive markets, IO models seem very suitable to study competitive issues in energy markets as there is ample empirical support that suppliers on these markets are able to manipulate prices (see e.g. Wolfram, 1999; Borenstein and Bushnell, 1999; Borenstein, Bushnell and Wolak, 2002).\footnote{In addition, in a recent report the European Commission (EC, 2007) states that consumers cannot reap the full benefits of the recent EU-energy market liberalization because suppliers still have substantial power to manipulate market outcomes.}

Although economic theory provides useful tools that can be used to restructure industries, turning regulated sectors into well-functioning markets where competitive forces prevail is far from trivial. It has been demonstrated that energy industries are among the most challenging ones to liberalize. This is not only caused by the institutional complexities surrounding these industries, but also by the fact that these sectors have been subject to substantial alterations along other dimensions. A main driver of these changes has been the growing concern about the environment. Due to the widespread consensus that the level of pollution caused by the energy sector should be reduced, markets for emission rights have been created. These emission rights put a cap on the level of a pollutant (e.g. greenhouse gases) that can be emitted. It is well-known that poorly designed markets for emission rights not only provide firms insufficient incentives to produce in a more environmentally friendly way, but also have a negative effect on the efficiency at the deregulated parts of the industries (see Newbery, 2008).\footnote{See also Stavins (2003) for an extensive analysis of the various market-based policy instruments that have been implemented worldwide to restrict pollution.}

Furthermore, environmental concerns and the recognition that the reserves of fossil fuels like oil, coal and natural gas are depleted at a rather fast rate have led to the development of renewable energy sources, like solar power and biomass. In 2007, the share of renewables in world electricity production was 18 percent and this fraction is expected to grow to 23 percent in 2035 (EIA, 2010).
Against this background, policy makers face the challenge to implement effective deregulation policies that bring about more competition and therefore lead to a higher market efficiency. This is important, since the availability of relatively cheap and reliable sources of energy is crucial for the performance of the economy as a whole. Energy sources are not only indispensable for households as they are utilized for heating, cooking and lighting purposes, but also for various industries where energy commodities are an essential input in the production process. For instance, natural gas is used by residential consumers to heat their houses but is also deployed in the production of electricity and ammonia.

This thesis contributes to a better understanding of market behavior in restructured energy industries, which ultimately could help in developing more adequate policy measures. Throughout the thesis, we will mainly focus on those parts of the value chain that have been opened up to competition. Since we are to believe that suppliers in these segments have considerable market power, as is mentioned above, our research primarily pertains to the domain of IO. Our analysis provides theoretical insights as well as empirical evidence on the strategic interactions between participants in energy markets.

Even though most of the research discussed in the following chapters applies to energy markets in general, our main focus will be on the wholesale market for natural gas. A first explanation for this choice is that most studies on deregulated energy industries deal with electricity markets, while gas markets have not received much attention in the literature so far. Admittedly, gas and power markets have a lot of common characteristics which may make it tempting to carry over insights gained about the electricity sector directly to the gas industry. While this may be true for many aspects, one should be aware of the way in which institutional dissimilarities between the two sectors call for different forms of market design. In Chapter 2 of this thesis, we will see that this is particularly true when it comes to the provision of transportation services and the pricing of it. Another reason for why we mainly concentrate on natural gas markets has a more pragmatic nature: we were able to collect a rather rich data set for this industry that provides us information about the number of active firms, the level of trade in spot and forward contracts and the amounts transacted over-the-counter and on centralized exchanges. These data will be used in Chapter 4, which is the only empirical study in this thesis.

Similar to most other regulated network sectors, natural gas industries used to be vertically integrated monopolies, state-owned or not, operating under regulatory constraints. These integrated firms possessed exclusive rights to buy from upstream
producers at regulated wellhead prices and sell to industrial users like power plants, to final users directly, or to local distribution companies (LDCs), who then in turn sold the gas to final consumers. When it gradually came to the surface that these monopolists were performing rather poorly in efficiency terms, the call for market deregulation grew louder. Some thirty years ago, the passage of the *Natural Gas Policy Act* in the U.S. and the *Gas Act* in the U.K. initiated the worldwide deregulation of gas markets with the main objective to let consumers reap the benefits from intensified competition in the market.

In the European Union, the liberalization started back in the early 1990s, but gained full momentum with the *First Gas Directive*. This ruling abolished import monopolies, forced the opening of markets and imposed the accounting unbundling of vertically integrated network companies. The deregulation of EU gas markets was furthered by the implementation of the *Second Gas Directive*, which required full market opening, regulated third party network access, regulated or negotiated access to storage and ownership unbundling of integrated companies. The Second Directive also required the creation of national energy regulators. Their main roles include the approval of transmission and distribution tariffs, ensuring entrants have access to the transmission networks and making sure the unbundling process is complete. The underlying objective of these measures is to ensure that all customers are able to freely choose among a significant number of gas suppliers.

Although the exact restructuring of markets differs from one country to another, virtually all deregulation policies implemented throughout the world share the same global structures. In the remainder of the Introduction, we will discuss in more detail the main policy actions that have characterized the liberalization of energy industries in general and natural gas markets in particular and explain how our research fits in the context of the restructuring of energy markets.

**Separation of transportation and wholesale supply**

Usually, one of the first steps taken in order to deregulate natural gas markets is to separate the provision of transportation services from merchant activities. That is, the firm that owns the transport infrastructure is not allowed to be active in gas trading any longer. Historically, in each geographical zone there was a vertically integrated monopolist in place who not only owned the transmission infrastructure but also had exclusive rights to buy from local and foreign producers and in turn to sell directly to consumers or to downstream distribution monopolies and industrial users. In order to limit the monopoly rents the price the network firm could charge
to its customers was regulated and usually linked to the oil price, while there also existed a cap on the profit the vertically integrated monopolist was allowed to earn. Due to this regulatory framework and a lack of competitive pressures, the incentives to reduce cost and to invest in infrastructure were rather weak.

By separating transportation services from trading activities, legislators have aimed to reduce market inefficiencies. Once the network company is no longer allowed to engage in trading activities, there is potentially scope for new firms to enter at the wholesale and retail levels. While these segments have been opened up to competition, the provision of transportation services remains to be regulated. The role of the network company, which in deregulated markets is usually called *transmission system operator* (TSO), has changed quite dramatically due to the reform policies. Whereas in the past the transport operator was mainly concerned with buying from upstream producers and in turn shipping and reselling the commodity to public utilities and industrial consumers, in restructured markets the business model of the transport operator mainly consists of allocating and pricing transport capacity, investing in new infrastructure, maintaining the existing network and balancing the transport system.

Clearly, the performance of the TSO has a decisive impact on overall market efficiency. For instance, since transport capacity is an essential input for wholesale firms, the extent to which suppliers have access to pipelines or power networks relates to the scope of energy market competitiveness. Transport capacity and access prices are thus two valuable instruments available to operators to enhance competition in energy markets. Since the TSO’s optimal choices regarding investments in infrastructure and the allocation and pricing of it are usually not aligned with what is best for society as a whole, the regulator is assigned the task to entice the transport operator to conduct business in a way that benefits final users of the energy source. Especially when network users have market power on the wholesale market, or when the transport operator still owns (or hold close ties to) a trading arm, or when the operator enjoys a information advantage over the regulator, finding the optimal regulatory framework is not a sinecure. Our research on the optimal regulation of a natural gas TSO, documented in Chapter 2, focuses on the problem of finding the optimal access pricing regime in case users of the network compete with

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5The European Commission has however raised the concern that there are still significant barriers to enter European energy wholesale markets. Among the most important reasons for the existence of entry barriers are inadequate unbundling of network operators, insufficient opportunities for cross-border trade and a lack of transparency in various market operations (see EC, 2007).
each other in an oligopolistic wholesale market.

The pricing and allocation of transmission rights affect the degree of competition in wholesale markets in various ways. For instance, since network capacity is an essential input for wholesale firms, the supply cost at the wholesale level is directly related to the pricing for access to the transmission network. High access prices may therefore lead to a lower supply in the wholesale market.

Regarding current natural gas markets, another important feature is that pipelines are frequently congested. Especially cross-border trade is hampered by a lack of available transit capacity, which implies that wholesale gas markets remain national in scope. Even in regions where pipeline capacity is relatively large, transmission rights are typically allocated to incumbents under contracts with long duration. This contractual congestion reduces the possibilities for entrants to ensure access to pipelines and therefore the opportunity to compete with incumbents. One way to alleviate the problem of contractual congestion is to apply the so-called use-it-or-lose-it principle, which means that contracted but unused transport capacity become available on a secondary market. Another solution that has been proposed is to deploy a different mechanism to allocate pipeline capacity. Instead of granting transmission rights based on a first-come, first-served rule, transmission rights could for instance be auctioned. An interesting way to alleviate physical congestion is the adoption of the netting mechanism. With netting, the TSO makes use of the fact that flows in reverse direction cancel out. This implies that the pipeline size only has to be large enough to accommodate the net flow, which is the difference between the contracted capacity in one direction and the contracted capacity in the opposite direction.

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6Joskow and Tirole (2000) study the effects of two different mechanisms to allocate transmission capacity in imperfectly competitive power markets. One mechanism relies on centralized pools where market participants can submit bids to buy or sell electricity. Based on these bids, the network operator decides which bidders are allowed to take or deliver electricity, taking into account the capacity constraint and the physical laws that govern power flows. The system operator may issue financial rights to buyers and generators to compensate them for price differences across nodes that occur in case of network congestion. Another method decentralizes the allocation of transmission by creating a market for physical rights. Under such an approach, electricity generators must hold physical rights to get their supplies dispatched by the operator.

7The incumbent suppliers at the wholesale level used to be the trading arms of the integrated monopolies. In some countries, these incumbents are still affiliated to the network company.

8In few natural gas markets around the world, auctions have been introduced to allocate network capacity. For instance, in 1999 the British network operator Transco introduced an auction for allocation of transport capacity (McDaniel and Neuhoff, 2004). In electricity, auctioning transmission rights is more common than in gas markets. See e.g. Gilbert, Neuhoff and Newbery (2004) and Fabra, von der Fehr and Harbord (2008) for work on how auction design impacts competition and therefore prices in oligopolistic power markets.
In the next chapter, we study the optimal regulated tariffs for gas transportation. Allowing for the use of netting, we explicitly distinguish between congested and non-congested pipelines. Considering oligopolistic wholesalers using the pipeline network to serve their customers, it is shown that regulated tariffs should not only be based on the particular cost structure of the TSO but should also mitigate the social loss from oligopoly. In case of congestion, the highest level of welfare is attained when the counterflow (backhaul) is subsidized while the dominant flow is taxed. The idea is that by subsidizing the counterflow, more backhaul gas is put in the pipeline system which alleviates network congestion and therefore leads to more supply at each entry/exit point in the network. This implies that the optimal tariff structure diverges from access pricing rules that only allow for cost recovery of the TSO. Furthermore, due to the fact that the gas industry differs from electricity sector with respect to the flow physics, the concept of nodal pricing, usually applied to price power transmission, is not optimal when charging the flow of natural gas.

We thus show that implementing sound regulatory rules on the TSO is key in creating well-functioning wholesale markets. While in Chapter 2 we assume that the operator is fully unbundled, finding the optimal regulatory framework becomes an even more difficult task when there still exist close ties between the network operator and a wholesale supplier. In this respect, it is important to note that in many countries the unbundling of the network firms is in a transition phase and that there still exist suppliers which are affiliated to the transport operator. The European Commission has raised the concern that the investment and allocation choices of integrated transport operators are partly driven by the interests of the affiliates. For instance, operators can foreclose access to transmission capacity for rival wholesalers. The literature on vertical foreclosure (see e.g. Katz, 1989; Ordover, Saloner and Salop, 1990; Rey and Tirole, 2007) tells us that the owner of an essential facility can foreclose downstream competitors in various ways, ranging from simply denying the use of the essential input to exercising price discrimination. Energy regulators have tried to fight this anti-competitive behavior by third-party access rules and

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9 Höffler and Wittman (2007) provide a discussion on the application of netting in electricity markets.

10 There is little further work on transportation pricing in the natural gas industry. Attention has mainly been given to optimal prices under different demand and cost structures in perfectly competitive markets (Cremer and Laffont, 2002; Cremer, Gasmi and Laffont, 2003).

11 We will elaborate more on the differences between the optimal pricing of gas and electricity transmission in the next chapter.
forbidding the operator to charge discriminatory access prices.\footnote{Third-party access rules force the operator to grant access to their network to non-affiliated firms.} Our research on optimal transport tariffs shows that obliging the TSO to set uniform transmission tariffs may not always be beneficial for welfare. Indeed, regulators should forbid transport operators to price discriminate on the basis of the identity of network users. However, price discriminating between firms that have different incentives aids to social welfare if it weakens the incentives to keep supply artificially low. For instance, in our model one of the wholesale suppliers has an incentive to congest the line, which calls for a discriminatory tariff structure where the dominant (backhaul) flow is taxed (subsidized).\footnote{We refer to Laffont and Tirole (1994) and Armstrong, Doyle and Vickers (1996) for further work on optimal access pricing in network industries. The main focus in these papers is on situations where a vertically integrated firm controls an essential input. Vogelsang (2003) presents a review of the research conducted on access pricing in telecommunications.}

Another complication that a regulator usually faces is that she has an information disadvantage vis-à-vis the regulated firm. For example, the company that is regulated knows better its own operating cost than the regulator does. Due to this informational asymmetry, the regulator faces an adverse selection problem as well as moral hazard on the monopolist’s side. The reason for being confronted with an adverse selection problem is that the regulator, not knowing the firm’s cost, is uncertain about the access price at which the transport operator can recover its cost and thus wants to stay in business. Obviously, the monopolist has an incentive to misreport its true costs to the regulator (Baron and Besanko, 1984). One way to overcome this particular information disadvantage is to set regulated prices that make up for the firm’s actual cost \textit{ex post}. Since the \textit{ex post} cost can usually be audited, the incentive for the firm to hide its true cost will be destroyed in this way. However, as this cost-plus or rate-of-return type of regulation fully compensates the regulated firm for the cost it bears there is little incentive to improve on efficiency. This moral hazard on the firm’s side further complicates the quest for the optimal regulatory policy.\footnote{This moral hazard problem relates to the well-known Averch-Johnson effect. Rate of return regulation dictates that a firm’s profit is restricted by a maximum rate of return on the firm’s tangible assets, which creates an incentive for regulated companies to overinvest (Averch and Johnson, 1962).}

Luckily, the literature on incentive regulation proves to be a useful guidance for the regulator (see e.g. Baron and Myerson, 1982; Laffont and Tirole, 2000). Probably the most valuable insight from the work on incentive regulation is that a
regulated monopolist should be offered a menu of contracts that leads to an incentive-compatible outcome: if the regulated firm is efficient, it chooses a high-powered incentive scheme and if it is less efficient, it chooses a lower-powered incentive scheme. Though in our chapter on optimal regulation we abstract away from asymmetric information issues, we recognize the importance of research in this field. In fact, introducing an information advantage at the operator’s side in the framework set out in the next chapter is an interesting starting point for further research.

Long-term commitment versus spot markets

As mentioned above, the regulated monopolies used to hold sole rights to buy from upstream producers and to sell to downstream utilities and industrial users. The conditions of trade in these long-lasting relationships were usually laid down in so-called take-or-pay contracts, which typically had a duration of 20 years or more (see e.g. Masten and Crocker, 1985; Hubbard and Weiner, 1986). This type of contract stipulates the per-period minimum amount of gas for which the buyer has to pay, even if this amount is not taken. While the purchaser thus fully bears the quantity risk, the seller is exposed to the price risk since the contract price is usually indexed to the oil price. This indexation protects the buyer against gas prices being higher than prices of competing fuels. In order to create more competition on both wholesale and retail markets, one of the ultimate goals of the unbundling of network companies is to shift trade from long-term bilateral contracts to short-term spot markets.

Examples of spot commodity markets that have been introduced in the electricity industry are the Pool in the U.K., ISO in California, the real-time PJM market in Pennsylvania, New Jersey and Maryland, ERCOT in Texas, EPEXSPOT in Austria, France, Germany and Switzerland. In the natural gas sector, we have seen the emergence of trading hubs where market parties can transact gas on a short-term basis. Examples of these gas hubs are NBP in the U.K., the Henry Hub in the U.S., the Zeebrugge Hub in Belgium and TTF in The Netherlands.\(^{15}\) The 2000-2001 electricity crisis in California has revealed that the combined prevalence of price risks and market power in energy markets may have fatal consequences when risk-hedging mechanisms are absent (Borenstein, 2002; Bushnell, 2004). As a

\(^{15}\)One development in natural gas has been the creation of virtual hubs, for example the NBP and TTF, as opposed to the more traditional physical hubs, like the Henry Hub and the Zeebrugge Hub. A physical hub is a location where several pipelines come together, so that total physical throughput is delivered at this point. By contrast, virtual hubs contain several entry and exit points that are interconnected, which implies that not all the gas traded has to flow through a single point in the pipeline system.
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consequence, in nowadays restructuring, it is widely held that spot markets must
necessarily be complemented with forward markets (Ausubel and Cramton, 2009).
In an attempt to aid firms to contract forward, in some markets we have witnessed
the creation of futures exchanges. Examples of markets for electricity futures are
CALPX in California and EEX Power Derivatives in Austria, France, Germany and
Switzerland; ENDEX runs a market for natural gas futures in The Netherlands, as
well as markets for U.K. and Dutch electricity futures.

The general idea is that well-functioning spot markets allocate scarce resources
more efficiently than bilateral negotiations because traders on a liquid spot market
are better able to exploit arbitrage opportunities, thereby bringing trade more in line
with changes in supply and demand. In addition, long-lasting relationships between
buyers and sellers can potentially exert an entry-deterrence effect, as is shown by
Aghion and Bolton (1987). The argument is that when incumbents have locked
in buyers by means of long-term contracts, the residual demand on the market
is relatively small. Potential entrants, not being able to attract sufficiently many
downstream costumers, do not find an opportunity to profitably enter the market.
Simpson and Wickelgren (2007) show that the entry-deterrence effect of long-term
contracts carries over to situations where buyers are downstream competitors instead
of final users. The basic intuition behind this result is that the contracts become
renegotiation-proof, since downstream firms pass on all benefits from breaching the
contract to final consumers while they are still charged the expectation damages.

Ultimately, the question becomes whether moving away from forward-based
transactions, either being conducted through bilateral contracts or taking place on
centralized futures exchanges, towards trade on a spot market is socially desirable.
The literature on forward contracting tells us that answering this question is not
straightforward, since trading forward has the potential to deliver social benefits on
several accounts. First, as has already been pointed out, forward contracts provide
buyers and sellers with an opportunity to hedge against price shocks in the spot
market. Without this possibility, the California crisis has demonstrated that firms,
being fully exposed to spot price volatility, run a serious risk of getting into financial
distress when a severe shock occurs. Moreover, research on competitive risk-averse
firms facing price uncertainty has shown that forward markets increase social wel-
fare through another channel. Firms which without the possibility to trade forward
would have reduced their output below the (full-certainty) competitive level, con-

\[16\] This setting thus resembles the wholesale segment in energy markets, where (most of the)
buyers are retailers that compete with each other to sell to residential users.
tract the competitive amount in the forward market if possible (see e.g. Baron, 1970; Holthausen, 1979; and Sandmo, 1971).

Second, when commodity markets are *imperfectly competitive* forward contracts can potentially have an additional pro-welfare effect. The basic idea, developed by Allaz and Vila (1993), is that firms use forward contracts as strategic commitment devices. By contracting (part of) their output in advance of the delivery period, a firm takes a smaller position in the spot market. This reduces its incentive to maintain a high spot price, which implies that the firm commits to a more aggressive strategy in the spot market. As a result, rival firms will adhere to a less aggressive spot strategy which generates a competitive advantage for the contracting firm. However, since all sellers are interested in taking a short position in the forward market to affect their competitors’ behavior in the spot market, they all end up playing a more aggressive strategy. Consequently, the final market outcome will be closer to the competitive one.

Some empirical support for the existence of this pro-competitive effect of forward trading in power markets is provided by Green (1999) and Wolak (2000). Studying the effect of vertical ties between wholesalers and retailers on market performance in three different U.S. electricity markets, Bushnell, Mansur and Saravia (2008) find evidence that wholesale firms which are vertically integrated or have long-lasting contractual arrangements with retailers behave more competitively than wholesalers which do not have strong links to downstream retailers. The reason for this is analogous to the intuition behind the result of Allaz and Vila: since retail prices in the markets studied by Bushnell et al. are rigid due to regulation or price commitments well in advance of delivery, vertically integrated firms sell part of their output against a fixed price. Again, this weakens the incentives to raise the price on the wholesale market.

Yet another reason why forward contracts with an extended duration may *ex ante* be more efficient than spot market trade is that these contracts avoid *ex post* bargaining. This relates to the well-known hold-up problem (Williamson, 1979), which occurs when one of the parties, say the seller, needs to invest in transaction-specific capital that cannot be used for other purposes (e.g. dedicated pipelines connecting production sites and the transmission network). If the buyer and seller repeatedly negotiate the terms of trade in short-term markets, the buyer has an incentive to renegotiate the terms of trade in order to obtain (part of) the rents from the seller’s investment once the transaction-specific capital is in place. The seller is thus unable to appropriate all rents from his investment, and as a result, he will underinvest. If, on the contrary, the seller and the buyer are locked into a long-lasting relationship due to a (renegotiation proof) contractual agreement, the seller is protected against opportunistic actions of the buyer as far into the future as the duration of the contract. Joskow (1987), studying bilateral contracts between coal producers and electricity utilities, finds empirical evidence that long-term contracts can be a solution to the hold-up problem.
The limited empirical evidence on the pro-competitive effect of forward contracts stems from markets where regulators have imposed obligations on large suppliers to sell part of their production (capacity) on a forward basis, often in the form of gas release programs and virtual power plants (VPPs). Therefore, whether forward institutions by themselves provide market players with sufficient incentives to trade forward is not well-understood yet. In addition, there exist other complicating factors that have precluded the proliferation of empirical work on forward contracting. For instance, due to confidentiality reasons it is difficult to get one’s hands on data about contracts. Further, even when equipped with a rich data set disentangling the various incentives to sell forward becomes a challenging task.

In the third chapter of this thesis, we show how the econometrician can empirically disentangle the different motives for forward contracting when having sufficient data at hand. Exploiting the equilibrium restrictions from an underlying model, we propose an empirical strategy to test whether sellers trade forward for risk-hedging reasons, for strategic motives, or both. Whether forward contracts can be used for strategic purposes crucially depends on their observability, as is shown by Kao and Hughes (1997). Therefore, market transparency is a necessary condition for the strategic motive of forward contracting to be present. Given that forward transactions are usually conducted anonymously, it is nearly impossible that suppliers become directly informed about their rivals’ forward positions. However, by looking at (changes in) forward prices market players could in principle be able to infer (aggregate) positions in the forward market. This suggests that the provision of reliable price information plays an important role in developing more competitive markets. In current gas markets, information about forward prices is delivered by information agencies, brokers’ associations and exchanges, typically in the form of price indices. The question then becomes whether market players are able to extract the necessary information from price indices, given that these indices are complex statistics, based on prices of a broad range of contracts that differ from each other in terms of duration, traded volume and so forth.

Thus, the extent to which strategic commitment through forward contracting is possible varies from market to market, depending on the prevailing level of transparency. When equipped with the adequate data set, the empirical strategy laid down in Chapter 3 provides the researcher with a way to test for the presence of strategic and/or risk-hedging incentives in a forward market. We show that identi-
fication of the strategic motive relies on variation in the number of active suppliers in the market. If the market is relatively transparent so firms can sell forward for strategic reasons, the theoretical model predicts that entry of new firms leads to a fall in the inverse hedge ratio of suppliers. By contrast, if the forward market is relatively opaque we expect the inverse hedge ratio to go up in the number of active sellers.

In Chapter 4, we apply this strategy to the Dutch wholesale market for natural gas. One of the most notable deregulation steps in this market was the opening of the Title Transfer Facility (TTF) in 2003. The TTF is a virtual trading hub where gas can easily change hands before it is taken out of the Dutch pipeline network at a certain exit point. The existence of the TTF enabled the arrival of gas exchanges for spot contracts (APX) and futures (ENDEX). Our data set consists of a large share of all (forward, spot and speculative) transactions that have been conducted at the TTF, for the period April 2003 through June 2008. We also have data on the number of active wholesalers for this period. Our empirical results suggest that suppliers at the TTF engage in forward contracting for strategic purposes. Given that most of this trade takes place in over-the-counter (OTC) markets, we believe this is an important result. OTC markets are often criticized for being relatively opaque, providing only little information about market conditions to participants. The Dutch forward market for natural gas however seems to be relatively transparent, because if not, forward contracts could not have been traded for strategic commitment reasons.

The introduction of centralized exchanges

Finally, we take a closer look at the market microstructure of energy markets, where we particularly focus on the role of organized exchanges in restructured energy markets. As markets for commodities have been created, the rather homogeneous nature of energy commodities makes it possible to standardize energy contracts which can be traded at centralized marketplaces. In recent years we have indeed witnessed the opening of various energy exchanges at the wholesale level, where market parties are typically offered the opportunity to trade spot contracts as well as energy derivatives, like futures and options. These exchanges usually operate business-to-business (B2B) platforms, which enable buyers and sellers to meet in the virtual marketplace. The emergence of B2B e-commerce is due to the information technology revolution.

\footnote{For some more information about the Dutch gas market and the TTF, we refer the interested reader to Chapter 4.}

\footnote{The theory of market microstructure studies institutional issues related to intermediation and exchange (see e.g. Spulber, 1996).}
as B2B trade is conducted electronically, predominantly through the web (see e.g. Lucking-Reiley and Spulber, 2001). In order to be able to make use of the services provided by the exchange, market parties usually have to subscribe to the exchange’s website.

The first and foremost raison d’être of centralized exchanges is the provision of intermediation services, thereby facilitating buyers and sellers to find a counterparty. By automating the processing of transaction-related data through the Internet or electronic data interchange, e-commerce lowers the cost for buyers and suppliers to conduct a transaction (Borenstein and Saloner, 2001). Further, B2B marketplaces typically reduce the counterparty risk for traders by providing immediacy and clearing services. Immediacy is usually provided by exchange brokers, who, by holding cash and inventory to stand ready to buy and sell, allow traders to conduct a deal immediately. This alleviates the double coincidence of wants problem, because the buyer and seller are no longer required to transact at the same moment in time. Clearing reduces a trader’s risk of non-delivery or non-payment in case of default by a counterparty, as clearing activities include the netting of offsetting positions, monitoring the creditworthiness of trading parties and requiring traders to keep a collateral deposit.

These benefits from electronic B2B trade thus have the potential to lure many buyers and sellers to the organized exchange. This has a reinforcing effect on the incentives to become active at the exchange, as buyers and sellers gain from finding more traders from the other side of the market at the centralized marketplace. This is due to two reasons. First, a high level of activity at the exchange increases the likelihood that a single trader finds a trading partner. This market liquidity lowers the cost of searching for a counterparty, while at the same time eliminates a trader’s price risk from delaying a transaction (Grossman and Miller, 1988). Second, as transactions at organized exchanges are based on a bidding mechanism an increase in the number of participants intensifies competitive pressures at both sides of the

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20 See Spulber (1996) for a broad discussion on the various services that are provided by B2B intermediaries.

21 Another potential advantage of organized exchanges is the relatively high degree of transparency in these institutions, providing important information about trading conditions to market participants. As mentioned above, the importance of market transparency is dealt with in Chapters 3 and 4 of this thesis.

22 As explained above, liquidity is sometimes provided by brokers who stand ready to buy or sell at any moment. When transactions conducted on the B2B platform are not intermediated by a broker, the exchange itself has to be sufficiently liquid to ensure buyers and sellers that they do not run the risk of not being matched with a counterparty.
Chapter 5 examines how the degree of liquidity and competition on electronic exchanges influences the decisions of market players to move away from bilateral negotiations and start trading on the centralized marketplaces. Though B2B platforms have the potential to deliver the benefits mentioned above, at first glance it is not clear that buyers and sellers always want to bypass the OTC market. For instance, given that organized exchanges only facilitate trade in standardized products with a high turnover rate, there may exist an incentive for traders to acquire more custom-made products in the decentralized market. This is especially an issue when market participants face idiosyncratic risk than cannot be hedged by the standardized contracts offered at the centralized marketplace (Duffie, Gărleanu and Pedersen, 2007; Duffie, Li and Lubke, 2010).

In Chapter 5, we show that an additional reason to rely on one-to-one negotiations instead of trading at an exchange is the ability to price discriminate in the OTC market. Letting buyers differ in their valuation for the product that is traded, we establish that in equilibrium both market institutions exist: high-valuation buyers, losing a large part of their surplus when being exposed to price-discriminating sellers, are willing to pay the exchange fee in order to trade at the B2B platform; low-valuation buyers, by contrast, turn to the decentralized market as they only have to give up a relatively small amount of the trading surplus as a result of bargaining.

Our finding that over-the-counter markets and organized exchanges can exist side by side is interesting given the fact that most other work on this topic suggests that in equilibrium trade takes place on only one of the two marketplaces. For instance, Baye and Morgan (2000; 2001), considering identical firms facing the problem of selling their product to homogeneous consumers on either local markets or a centralized website operated by a gatekeeper, come to the result that the gatekeeper sets subscription fees that lure all buyers to the centralized platform. This also implies that all transactions are conducted through the website, leaving the local markets empty. Considering firms that offer differentiated products instead of homogeneous goods, Galeotti and Moraga-González (2009) also establish that the platform manager charges both sides of the market such that all trade takes place on the platform. Our model differs from the settings studied by Baye and Morgan and Galeotti and Moraga-González in that we assume that consumers are heterogeneous in their willingness to pay, which allows suppliers to engage in price discrimination in over-the-counter negotiations. This makes the OTC market for some buyers relatively more attractive than for others, hence we obtain segmentation on the buyer’s
side of the market.

We take the view that buyer segmentation indeed plays a role in present energy markets. Despite the aim of policy makers to develop highly liquid energy exchanges, we observe that most energy contracts are still transacted over-the-counter. For example, as is also discussed in more detail in Chapter 4, the Dutch gas market is currently characterized by a fairly low share of centralized trade. In 2008, about 20 percent of the high-calorific gas transacted in the Netherlands passed the TTF. Concerning trade in the power sector, we note that volumes bought and sold at the European electricity spot exchanges EEX (Germany), APX (The Netherlands) and Powernext (France) accounted for respectively 17, 13 and 4 percent of total national consumption in 2008 (see EC, 2007). Even in countries where energy exchanges have matured, a sizeable number of transactions takes place in decentralized marketplaces. For instance, about 67 percent of the 2007 U.K. gas consumption passed the National Balancing Point (NBP), which is the natural gas hub in the U.K. However, a substantial part of the NBP transactions are conducted over-the-counter.

It seems reasonable to believe that the coexistence of centralized and decentralized trade in energy markets is due to the presence of various types of buyers who differ in their valuation for the energy source. Considering the wholesale market for natural gas, we notice that the buyer’s side consists of a variety of different types of buyers, like retailers, industrial users and speculative traders. In this respect, it is interesting to see that in the Dutch gas market industrial users fully rely on the OTC market when buying gas and thus ignore the centralized hub TTF completely. The decentralized market may be more attractive for this type of consumers because OTC-traded contracts provide the necessary level of flexibility these buyers require, but it could also be due to industrial users having a relatively low willingness to pay for gas. Given that industrial costumers like electricity producers usually have the opportunity to substitute away the use of gas in their production process if the gas price becomes too high, this seems to be a plausible explanation.

The discussion above has already touched upon the main issues we study in the core of this thesis, which consists of Chapters 2 through 5. The thesis ends with a chapter containing the main conclusions and policy recommendations that follow from our research. That chapter also provides some ideas for further research.