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End user prices in liberalised energy markets

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Abstract

As European energy markets move towards deregulation, energy prices shift from classic‘cost plus’ prices towards market prices. We develop a model for the retail and wholesale energy markets in Europe, based on Bertrand competition in a two part pricing structure with switching costs. We use the model to forecast end user electricity and natural gas prices and find that the introduction of competition in energy retail and wholesale markets will decrease standing charges, lowering total costs for energy users. A larger number of entrants, a cost advantage for one of the suppliers, or lower switching costs reduces standing charges further.

JEL-codes: D43, L13, L22, L94, L95, Q41

1 Introduction

Europe's energy was traditionally supplied by national and regional monopolies, often with a strong public sector influence. The European Commission has developed a policy aimed at the liberalisation and (European) integration of electricity and natural gas markets. Liberalisation is believed to have a positive impact on allocative and productive efficiency. Furthermore, liberalisation is seen as a necessary condition for the integration of national markets to one European market, since the single market requires unrestricted trade.

With the UK and the Nordic countries leading the way, Europe is now heading towards deregulated energy markets. The changes proposed by the European Commission are designed to promote competition between European energy suppliers. By 2007, all European energy markets should be open to entry by other EU-firms. Non-discriminatory access to networks should be provided in order to facilitate the expansion of international and interregional trade.

Like in many other European countries, the Dutch government has already taken up the task provided by the European Commission and gradually phased competition into energy markets. Large and medium energy users are already free to choose their providers, and small end-users will be able to do so in 2004 at the latest. The Electricity Act of 1998 and the Gas Act of 2000 formally establish the new structures of the respective markets.

Both electricity and gas are transported through networks and sold to end users by retailers and wholesalers. For the end user, the retailer or wholesaler is the prime contact with the energy sector. Being literally at the end of the pipeline, they ultimately determine end user prices of energy, thus impacting both energy use and consumer expenditures on energy. This paper addresses the question of the development of energy end user prices in the period 2002-2010.

Until recently, energy retail was a part of traditional utilities and hardly got any attention in economic literature. The liberalisation of energy markets in the US and the UK has induced some research on the matter. Goett et al. (2000) examine the willingness to pay for service attributes of retail energy suppliers. Using conjoint-type experiments, they assess willingness to pay values for over 40 attributes, among which brand familiarity, outages, discounts and energy sources. Green (2000) develops an energy retail model where consumers experience both switching costs and positive utility of buying from an entrant. Green shows numerically that the incumbent may use its favourable position to charge a higher price than entrants do and that the removal of tariff regulations may lead to a decrease in welfare because of persistent market power, due to switching costs.

Energy retail markets are to a certain extent comparable to telecommunications market. In both types of markets, retailers sell a good to end users and deliver it through a network. The network is owned by a monopolist, which often has some ties with one of the retailers. Laffont et al. (1997, 1998a and 1998b) build an oligopoly telecommunication model with Bertrand competition in two part tariffs. Operators offer their product at marginal costs and use the standing charge to extract rents. De Bijl (2000) extends the base model from Laffont et al. (1998b) to construct a model to analyse strategic behaviour of both upstream and downstream firms.

A large part of the literature on energy distribution is dedicated to access pricing, mainly to discussing the Efficient Components Pricing Rule (ECPR).[1] Furthermore, access pricing under vertical integration between upstream (network owners) and downstream (retailers) firms is discussed. Vertical integration brings about the problem that the behaviour of the upstream firm is influenced by its downstream consequences and vice versa. Prosperetti (2000) shows that producers who are vertically integrated with the network owner have little incentive to strive for competitive markets. They are inclined to use network access as a means to discourage entry or hinder competition on the downstream market. Borenstein et al. (2000) use similar arguments, stating that it may be profitable to induce congestion and become a monopolist on residual demand.

The remainder of this paper is organised as follows. Chapter 2 sets out the framework for our further analysis. In chapter 3, we develop a model of retail and wholesale in energy markets. Numerical simulations are presented in chapter 4 and chapter 5 concludes the paper, discussing the outcomes and addressing questions for further research.

[1] See Baumol, et al., (1997) for an overview of this discussion.

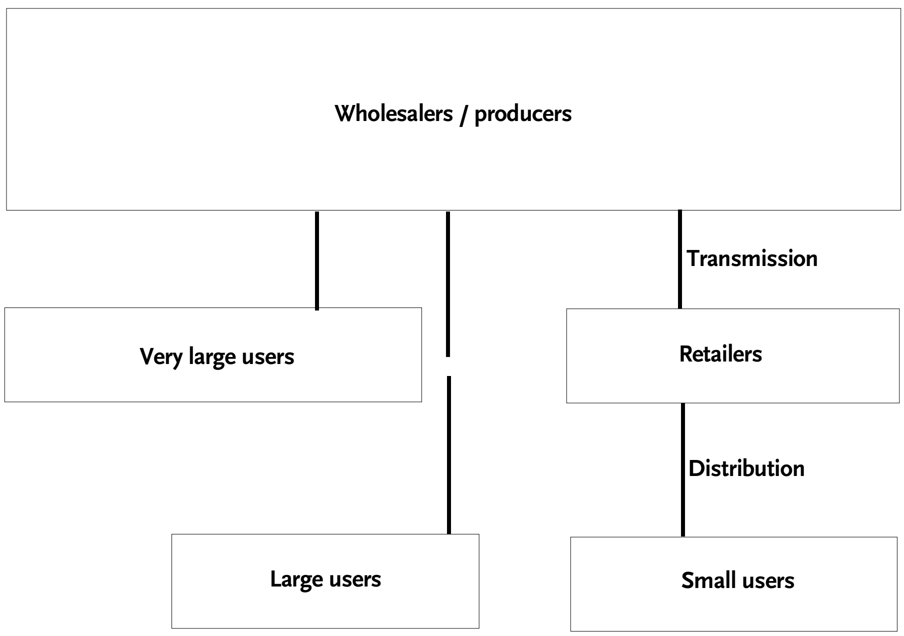
2 Framework

2.1 General outline

The provision of energy to end users takes place at several levels. These levels differ in type of trader involved as well in the type of network used to deliver the energy to the customer. Typically, electricity is transported through the national high voltage network and through regional networks at a lower voltage. The former is called the transmission grid, the latter are known as distribution networks. Very large users receive their electricity straight from the transmission network. Natural gas is transported in a similar manner, be it that pressure should be read for voltage.

Large and very large users buy their energy from wholesalers. In electricity markets, producers often act as wholesalers themselves. Small users buy their energy from retailers. This leaves us with three types of markets: the retail market, the wholesale market and a market where retailers buy energy from wholesalers.[2] Figure 2.1 graphically represents the distinctions described above.

Figure 2.1 Distinction between levels in energy markets



[2] Electricity is also traded at power exchanges. They are beyond the scope of our paper however. We concentrate on bilateral trade.

Note that the left and upper part of figure 2.1 are organised at a national (sometimes international) level, whereas retail and distribution take place at a regional level. A region's location and borders follow from the historical development of utility regions. The regional character of competition does not imply that retail is limited to regional companies. Retailers may be active in more than one region and even engage in competition in regions in other EU countries. Obviously, some regions may be more attractive for retailers to compete for than other regions (e.g. because of higher density), which may result in regional differences in the number of retailers.

In figure 2.1 we distinguish between small, large and very large users, because the price these groups pay for their energy consists of different components. Very large users receive their energy from wholesalers directly from the transmission grid, implying they pay for the commodity, wholesale costs and margins and transmission costs and margins. Normal large users also buy their energy from wholesalers, but the energy is delivered through distribution networks. This implies that they pay for distribution costs and margins on top of the components mentioned above. Small users buy their energy from retailers, adding retail costs and margins to the price.

The distinction of user groups leads to the practical problem of identifying these groups. For consistency with our national demand model NEMO, we use sector classifications for this distinction. Note that the classification applies to average rather than total consumption. If a sector is 'small', this does not necessarily mean that it uses a small amount of energy. Households for instance, account for about one third of total natural gas consumption in the Netherlands. Our classification in sectors implies some loss of information, because individual firms may deviate in size from other firms in the same sector. Table 2.1 shows the sector classification for natural gas and electricity.

Table 2.1 Size classification of sectors

	Natural gas	Electricity
small (1 to 6)	households, services, transport, government, construction, agriculture[a]	households, services, government, construction, horticulture, agriculture[a]
large (7 to 13)	horticulture, food industry, textile industry, paper industry, metal products industry, building materials industry, other industry[b]	transport, food industry, textile industry, paper industry, metal products industry, building materials industry, other industry[b]
very large (14 to 19)	iron and steel, non-ferrous basic metal industry, organic chemical industry, inorganic chemical industry, other chemical industry, fertilizer industry	iron and steel, non-ferrous basic metal industry, organic chemical industry, inorganic chemical industry, other chemical industry, fertilizer industry

[a] other than horticulture
[b] all industrial sectors not mentioned in any of the other classifications

The classification of sectors is very similar for natural gas and electricity, the only difference being the classification of the transport and horticulture sectors. Electricity use of the Dutch transport sector is almost completely realized by the national railways and the main international airport, both being large users. This implies that the average electricity price of the transport sector is mainly determined by the price for large users. With respect to natural gas, no large users are found in the transport sector, therefore it is classified as a sector of small users.

The exact opposite goes for horticulture. This sector is dominated by the use of greenhouses, with gas being the main heating fuel. Although horticulture companies differ greatly in size, the general picture suggests that they are large gas users. This is strengthened by the fact that greenhouse owners tend to be regionally concentrated and thoroughly organized, which enables them to combine their buyer power. Most horticulture firms are fairly small electricity users, despite the fact that they have to light the greenhouses, since they provide their own electricity through combined generation of heat and power.

2.2 Components of end user energy prices

End user prices consist of three main components; costs, profit margins and taxes. We discuss cost components first, of which the commodity price is of course one of the most important. The formation of commodity prices of natural gas and electricity are discussed in Kingma, Lijesen and Mulder (2002) and Mannaerts, Lijesen and Mulder (2002) respectively. Section 2.4 discusses the costs attached to energy transport. In the current section, we will focus on the remaining cost drivers and on factors that determine profit margins.

One cost component is related to the (practical) impossibility to store energy.[3] One unit of energy taken of a network should be directly replaced by a new unit, otherwise the voltage (electricity) or pressure (natural gas) drops. In other words: production and consumption should be balanced over time. Spare capacity is required to allow consumption to be flexible by time of day, which comes at a cost. Retailers have possibilities to retain the balancing costs they impose and thus gain a competitive advantage.

Each customer has his own demand pattern by time of day. Since demand peaks of individual customers are not completely equal, they net out to a certain extent, bringing balancing costs per customer down. Retailers play an important role here, acting as intermediaries between supply of and demand for energy. Retailers provide flexibility by time of day to the individual consumer.

Metering and billing costs are essentially linked to customers rather than output. No matter how small or large the amount used, consumption has to be measured and a bill has to be sent. This implies that some of the costs in retail are fixed costs per customer. Retailers obviously also make other costs that any firm would make, such as legal costs, advertising costs and overhead costs.

[3] This argument relates mainly to electricity, although the possibility of natural gas storage is also limited.

Economies of scale, scope and density

The question whether economies or diseconomies of scale, scope and density exist, is important for the formulation of a cost function in the retail model. Economies of scale refer to the relation between average costs and size of production. Positive economies of scale may arise from better utilization of indivisible production factors or from specialisation. Negative scale economies may arise because of coordination costs. Economies of scope refer to cost effects of the joint production of two or more goods. Positive economies of scope are predominantly associated with by-products. For products with a strong spatial component, economies of density are also relevant.

Economies of density is a spatial respecification of the concept of economies of scale rather than a different concept. Roberts (1986) divides between two types of density: output density and customer density. Output density (Q/N) is said to increase if output (Q) increases, while the number of customers (N) and the size of the service area (A) remain constant. If we increase the number of customers, leaving the output per customer and the size of the service area unchanged, we induce an increase in customer density (N/A). From these definitions, it follows logically that total output is defined as the size of the service area, times output density, times customer density. Economies of scale can therefore be divided into economies of output density, economies of customer density and economies of size.

Distinguishing economies of size in energy retail seems a bit awkward, since area size is an exogenous factor. For individual energy retailers it is however a relevant policy variable, since any firm chooses in how many and which regions to enter. Filippini (1998) finds constant returns with respect to size for distribution (integrated retail and transport) companies in Switzerland. No empirical research on economies of size in energy retail is available yet, since the division between retail and transport is of a recent date. Higher efficiency of national advertising campaigns may induce positive economies of size, whereas interregional coordination costs are likely to induce diseconomies.

Increasing returns to density are commonly found in network sectors, but they mainly come from transport costs rather than from retail. Some of retail's cost-drivers may however be subject to positive economies of customer density, such as advertising costs, balancing costs and metering costs. Positive economies of output density may occur because some cost-drivers are customer related rather than output related, such as billing costs.

Economies of scope may either relate to the horizontal scope (multi-product retail) or the vertical scope (retail and transport, retail and production). Armstrong and Leppel (1994) and Sing (1987) find no evidence of economies of scope for the joint distribution and retail of gas and electricity. No empirical research exists on the question of economies of scope between retail and transport or retail and production. There is no apparent reason to assume the presence of positive economies of scope here.

In brief, economies of density are the only type of scale economies likely to exist in energy retail. Like all types of scale economies, these economies of density are likely to become exhausted at a certain level of density. The question at which level exhaustion occurs is an empirical one. The considerations mentioned above suggest that a linear cost function will describe reality adequately.

Profit margins in retail depend on market power, which in turn has several driving forces. The number of suppliers is obviously an important factor, especially seen from the starting point of regional monopolies. Switching costs are another source of market power. By switching costs we do not necessarily mean costs attached to switching suppliers, it may also contain other reasons why customers do not switch, such as unfamiliarity with the existence of other suppliers, and brand loyalty.

Klemperer (1987) concludes that, under the assumption of constant consumer tastes, switching costs induce higher prices and higher profits. Markets with switching costs are less competitive than markets without these costs. De Bijl (2000) incorporates switching costs and initial market shares into a model based on that in Laffont *et al.* (1998a). This combination allows a repeated static model to represent the dynamic nature of competition.[4]

Green (2000) develops an energy retail model where consumers experience switching costs as well as value added of buying from an entrant. Both switching costs and value added are assumed to be uniformly distributed. Green shows numerically that the incumbent may use its favourable position to charge a higher price than entrants do. This finding is consistent with the results of De Bijl (2000), who finds that a high initial market share acts as a source of rent. Green (2000) also establishes that the removal of tariff regulations may lead to a decrease in welfare because of persistent market power, leading to higher prices. The persistence of market power is due to slow switching caused by the presence of switching costs.

Goett et al. (2000) examine factors that determine retail energy suppliers' choice by customers. Among many other things, they find that customers are willing to pay more for supply by their local electric company. This confirms that switching costs play a role in provider choice. They also find that 14 percent of customers prefer an unfamiliar utility, indicating that there is room for entry despite the bias towards the incumbent.

The factors mentioned in this section can be used to explain the difference in prices between types of users. Let us demonstrate this using both extremes in the case of electricity: a round-the-clock industrial company in basic metals versus a household.

First of all, the commodity price itself is lower for the industrial customer, since it requires base load electricity, which is produced at lower marginal costs than peak load electricity.[5] Similarly, balancing costs are lower, since the usage pattern is more predictable.

Transport costs are lower for a large industrial firm than for households for two reasons. First of all, the constant usage pattern implies a lower demand for capacity per unit of

[4] Note however that firm strategy is still static in such a model. This may be interpreted as short run profit maximization.

[5] See Mannaerts *et al.*, 2002.

consumption. Second, a very large user may be connected to the transmission grid directly, saving out on the costs of the distribution network.

As we have seen earlier, some of the costs are related to customers rather than to the amount of energy delivered. This implies that large customers may benefit from denominator effects, leading to lower total costs per unit. This may also be the case for switching costs: For customers with high demand volumes, it is worthwhile to investigate all possible options in supplier choice, which results in smaller retail margins in comparison to households, who may not be aware of all choice alternatives, since their search costs are higher relative to their demand volume.

2.3 Two part tariffs

As we mentioned earlier, energy retail costs may be divided between costs per unit sold and costs per customer. This implies that it would be efficient to price likewise, which is what we actually observe: energy is sold at so-called two part tariffs, consisting of a per unit price and a fixed fee, also known as the standing charge.[6]

Contemporary models of oligopolistic competition in networks often use two part tariffs pricing schemes, existing of a fixed fee and a per unit price. Oi (1971) was the first to study two part pricing, and many have followed, mostly relating it to monopoly settings. The main feature in two part pricing models is that the per unit price equals marginal costs, whereas rents are collected through the standing charge. Calem and Spulber (1984) confirm the intuition that firms in an oligopoly would set unit prices equal to marginal cost, whereas the standing charge is used both to compete for market share as well as to extract rents.

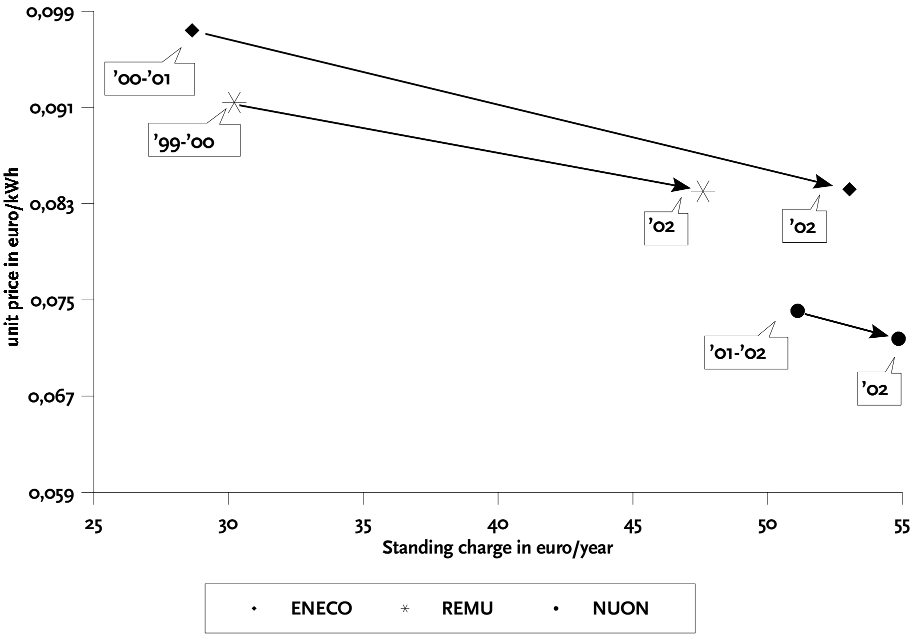
Recent publications show that these findings also hold for quantity competition in products and subscription (Kanemoto (2000)) and for quantity competition in products and price competition in standing charges (Harrison and Kline (2001)). Laffont *et al.* (1997, 1998a and 1998b) use two part tariffs in oligopoly network settings models. Their findings are similar to those in Calem and Spulber (1984).

Recent price developments for households show that the actual situation has shifted towards the theoretical optimum. Figure 2.2 graphs recent developments standing charges versus unit prices for the three large retailers in the western part of the Netherlands. Although years of measurement differ and the number of observations is too small to draw robust conclusions, the figure suggests a shift from unit prices to standing charges. Per unit prices are currently close to their approximated cost levels (including transport and retail costs, excluding taxes),

[6] The term 'access fee' or 'access charge' is also used to reflect the fixed fee in the two part tariff. This may however give rise to confusion with the fee paid to gain access to the network.

which implies the transition phase from traditional utilities to rational profit maximizing firms is now reaching its completion.

Figure 2.2 Recent developments in standing charges and per unit prices in the Netherlands



2.4 Network pricing

Transport over networks is characterized by large fixed costs and low marginal costs. Large economies of density and inefficiency of network duplication imply that networks are probably natural monopolies. At the same time, networks form an essential facility for the delivery of electricity and natural gas to the consumer. Like in other network sectors, third party access to the network is an important condition for effective competition.[7] Third party access refers both to the possibility of access as to the conditions under which it takes place. One important condition is of course the price under which access is granted, the access fee.

Like end user prices, the network access fee has a two part structure. The combination of (natural) monopoly and the essential facility feature require some form of price regulation, either direct or light handed. In the Netherlands, the both parts of the access fee are subject to price controls by the regulator, with the exception of the natural gas transmission fee system,

[7] See, for instance Laffont *et al.* (1998a), Lewis and Sappington (1999) and Granderson (2000)

which is currently negotiated with potential entrants and subject to arbitration by the regulator. Both the regulated and the negotiated access fees are non-discriminatory and publicly available.

The access fee requires special attention if the network firm is also a retailer or wholesaler, i.e. if trade and transport are vertically integrated. The network owner now has an incentive to deter entry through the access fee. Even if trade and transport activities of a firm are formally separated, the incentive remains as long as ownership is in the same hands.

Riechman (2000) considers the case with a vertically integrated monopolist in a segmented (by size of clients) market, as is the case in most European energy markets today. Riechman finds that a grid owner has incentives to differentiate its access charges strategically. His main finding is that the network firm will set lower access charges in segments where his own retail activities have a competitive advantage over its competitors and vice versa. Riechman also finds that systems of separate accounts for competitive and monopolistic activities, also known as 'financial ring fencing' or 'Chinese walls', leave room for entry deterring access charge structures.

Likewise, as Prosperetti (2000) points out, network owners who are vertically integrated with the incumbent producer have little incentive to strive for competitive markets. They are inclined to use network access as a means to discourage entry or hinder competition. Borenstein et al. (2000) use similar arguments, stating that it may be profitable to induce congestion and become a monopolist on residual demand.

On the other hand, vertical integration in markets where market power exists prevents double marginalization, as Tirole (1988) has shown. Double marginalization arises when firms at different places in a supply chain (e,g. a trader and a transporter) both have market power. They will both use their market power to receive a positive margin on their product. Tirole shows that if these firms would be vertically integrated, the total (single) margin would be lower than the sum of margins in the disintegrated case.

2.5 Some recent developments

Recent developments in wholesale, retail and transport of energy in the Netherlands may shed some light on developments to come. The retail market has experienced a process of regional concentration in the 1990s. The number of retailers has fallen from 51 in 1992 to 15 in 2000. Four out of these fifteen players are generally considered to be national players in market segments already open to competition. Striving against the stream of concentration is a handful of entrants in the newly liberalised market segments. They are mainly low-priced retailers trying to fight their way into the market. A few niche players have also entered, most of them aiming at residential users of so called green electricity.

Several market segments have already opened up in the Netherlands, providing us with valuable insights into the coming opening of consumer markets. Very large electricity users have free choice of suppliers since 1999. Although little is known about shifts in market shares and the content of individual contracts, the general impression is that prices have gone down considerably.

At the opening of the large user segment of the market for natural gas, the Netherlands' main wholesaler Gasunie lost a quarter of its market share, mainly to suppliers from the UK. At that time, in 1999 and 2000, UK gas prices were considerably lower than those at the continent, giving a strong incentive for users to switch. Some competition for medium-sized users has also developed at regional retail markets, albeit less spectacular.

The opening of the market for green electricity for all users is also very illustrative, maybe even more so than the opening of markets for large users, which hardly involves retail. Prior to the opening, the four large retailers started advertising campaigns to enlarge their brand familiarity and to push their green image. Each of the retailers started attracting new customers outside their own region and a few new retailers entered the market. Although retailers competed, end users prices were hardly affected. This may probably be due to the fact that buyers of green energy are less price sensitive. Advertisement campaigns focussed on the 'green image' rather than on prices. Another reason for not lowering prices may be that green generating capacity is scarce, as is import capacity, This does however not explain why retailers do not use their standing charge to attract customers.

The market for medium-sized electricity and gas users opened up In January 2002, causing 20 percent of the customers in this range to switch suppliers. The general image looks familiar: the four large retailers enter each others region and the same entrants appear in the market place. The similarities with the opening of the market for green electricity are striking and suggest a pattern that is likely to repeat in 2004, when all customers will become free to choose their supplier.

3 A model of Retail And Wholesale energy markets

3.1 The retail market

This section describes competition in the retail markets for electricity and natural gas. Since retail and wholesale markets are only marginally different, this section also serves as a description of the base elements for the wholesale market in the following section.

We describe a market where consumers buy energy from retailers. The number of retailers is determined exogenously. Consider the case where a representative consumer in sector s purchases energy from retailer i. His net utility consists of the utility gained from being a customer of firm i and from consuming the energy minus the out of pocket costs. Being firm i's customer is a necessary condition to buy from firm i, and therefore yields positive fixed utility.[8] We define utility to be measured in monetary units, in order to be able to extract out of pocket expenses. These expenses consist of standing charge m_{is} and the unit price of energy (p_{is}) times the amount consumed (x_{is}), all of which are sector specific. This yields the following equation for net utility:

$$v_{is} = u_{is}^{0} + u_{is} - p_{is} x_{is} - m_{is} \tag{1}$$

where u_i° is the utility of being connected to provider i, p_{is} is the per unit price of firm i for sector s, m_{is} denotes the standing charge for being connected to provider i and u_{is} represents a strictly concave (i.e. $\partial u_{is} / \partial x_{is} > 0$ and $\partial^2 u_{is} / \partial x_{is}^2 < 0$) utility function of buying x_{is} units of energy:

$$u_{is} = a x_{is} - \tfrac{1}{2} b x_{is}^2 \tag{2}$$

We will leave provider choice aside for now and turn to demand first. Given the choice for provider i, individual demand is based on utility maximization and therefore satisfies the first order condition of equation (1) with respect to x_{is}. This may be written as a linear demand equation for the representative customer in sector s of retailer i:

$$x_{is} = \frac{a_s - p_{is}}{b_s} \tag{3}$$

[8] We assume that a customer can buy from a single retailer only. We allow fixed utility to differ between providers, because of differences in brand familiarity, certainty of delivery, careful billing and so on.

Our next step is to model provider choice. Note that this is a discrete choice, every customer chooses one retailer. We assume customers to switch between providers based on the net utility they offer. The representative consumer will switch from firm i to firm j if $v_{is} < v_{js}$.

Obviously, this would imply that even the smallest difference in net utility would lead to the extreme outcome where one firm has a market share of one, leaving the other firms without customers. In real life, we don't see this kind of developments, for instance because of differences in preferences, brand loyalty, unawareness of alternatives, transaction costs and so on. Following De Bijl (2000), we model this by introducing switching costs, z_s.[9] The representative customer will now switch from provider i to provider j if $v_{is} < v_{js} - z_s$.

We assume that z is distributed uniformly on the interval $[0, Z_s\, s_{is,\,t-1}]$, where Z_s is a positive constant and $s_{is,\,t-1}$ is the lagged market share of producer i in sector s. The influence of the lagged market share on the upper bound of switching costs reflects the advantage of the customer's current retailer in terms of customer loyalty and unfamiliarity with alternatives. From the uniform distribution of z_s, it follows that the market share of firm i equals:[10]

$$s_{is} = s_{is,t-1} + \frac{v_{is} - \max(v_{js})}{Z_s} \qquad \text{if } v_{is} < \max(v_{js}) \qquad (4a)$$

$$s_{is} = s_{is,t-1} + \sum_{j=1}^{k} \frac{v_{is} - v_{js}}{Z_s} \qquad \text{if } v_{is} = \max(v_{js}) \qquad (4b)$$

where k is the number of retailers. From this equation, we can see that Z_s, the upper bound of switching costs, is an inverse measure for the sensitivity of consumers in sector s to differences between suppliers' attributes and therefore a measure of the volatility of market shares.

Our model divides between purchase costs, connection-dependent transport costs and traffic-dependent transport costs. Purchase costs are defined as the sum of the wholesale price and transaction costs that go with the purchase of energy (e.g. search costs, negotiation costs and so

[9] An alternative to this solution is the use of the logit equation. This type of equation is however fit to reflect taste differences rather than switching costs. Note that a strict interpretation of switching costs implies that traders base prices on long run profit maximization. Here, we ignore this implication, which implies a loose interpretation of switching costs, e.g. unawareness of alternatives.

[10] See Annex I for the derivation of equations (4a) and (4b). Note that we define market share as the share of customers connected to a retailer rather than the share of sales.

on). We define connection-dependent transport costs as a fixed amount, $f_{is} > 0$, per customer, which contains costs for billing and servicing. Furthermore, a fixed access fee per customer, $m^d_{\tau s}$, is paid to the network owner. Transport costs consist of access fee $p^d_{\tau s}$ per unit of energy transported. Total costs of firm i now amount to:

$$C_i = \sum_{s=1}^{6} n_s s_{is} (f_{is} + m^d_{\tau s} + (pc_{is} + p^d_{\tau s}) x_{is}) \tag{5}$$

Where summation over sectors 1 to 6 reflects that only small users are involved. From the demand and cost systems above, we can deduct the profit function for each firm, by subtracting costs from revenues:

$$\pi_i = \sum_{s=1}^{6} n_s s_{is} (m_{is} - f_{is} - m^d_{\tau s} + (p_{is} - pc_{is} - p^d_{\tau s}) x_{is}) \tag{6}$$

Solving the model requires maximizing equation (6) with respect to m_{is} and p_{is} for each retailer i and sector s. Profit maximization implies that each firm sets its unit price at the marginal cost level, while collecting rents and capturing and retaining market share through manipulation of the standing charge. Such outcomes are typical for this type of model. Note that a firm with a cost advantage in the per unit costs will both increase its market share through a lower unit price and raise its standing charge to collect rents.

3.2 The wholesale market

Wholesale markets and retail markets are essentially the same, albeit that some differences occur in the interpretation of the variables. The model described in the previous section serves as a basis for the description here, because of the similarity. We replace subscripts i by subscripts g, to denote wholesalers rather than retailers.

As figure 2.1 suggests, wholesalers have three types of customers: large users, very large users and retailers. The first group is connected to a distribution network, so for the energy to be delivered, it has to pass both the transmission network as well as the distribution network. This implies that we should alter the cost function to reflect the costs of a wholesaler serving a large user (sectors 7 to 13 are large users):

$$C_g = \sum_{s=7}^{13} n_s s_{gs} (f_{gs} + m^d_{\tau s} + (pc_{gs} + p^d_{\tau s} + p^t_{\tau s}) x_{gs}) \tag{5'}$$

Obviously, the profit function is adjusted likewise. Apart from the subscripts, the only difference with equation (5) is that we have added a second type of access fee: the per unit access fee for transport over the transmission grid. Note that this fee is in the cost equation for retailers as well, though implicitly through the wholesale price, as we will see later on. Since large users are not connected to the transmission grid directly (see figure 2.1), they do not pay a standing charge for transmission access.

Very large users have to pay such a standing charge, whereas the per unit transmission grid access fee replaces rather than adds to the per unit distribution grid access fee. A wholesaler serving these users will bear the following costs:

$$C_g = \sum_{s=14}^{19} n_s s_{gs} (f_{gs} + m_{ts}^t + (pc_{gs} + p_{ts}^t) x_{gs}) \qquad (5'')$$

Where sector subscripts 14 to 19 indicate very large users. Again, equation (5”) goes with a similar adjustment of the profit function and wholesalers maximize profit through *m* and p. For the large and very large users, this rounds up the model description.

For retailers, in their role of customers to wholesalers, the case is slightly different. Since retailers are not end users, they do not derive utility from consuming energy. Instead, they derive a profit from selling the energy to end users. Therefore, their energy demand may be derived from the energy demand of their customers. Furthermore, we assume that retailers are not restricted to buy from one wholesaler. We would like to retain the two-part structure of the model. In the structure of the model it is however irrational to buy from more than one seller, because this would imply paying a multiple standing charge. We solve this problem by interpreting each retailer as a group of identical customers, comparable to the framework in the retail model. An alternative interpretation would be a set of bilateral contracts, each with a standing charge. For consistency, we would like the total of standing charges paid by an individual retailer to add up to a ‘normal’ level, i.e. a level that is comparable to the standing charge in a situation where the restriction of buying at only one wholesaler would have been in place. Otherwise, the irrationality of buying from multiple sellers would persist.

Let us define $s_{i,g}$ as the share of retailer i’s purchases (virtual customers or bilateral contracts as described in the previous paragraph) bought from wholesaler g, or in other words, firm g’s market share in i’s purchases. By definition, these shares add up to unity:

$$\sum_{g=1}^{I} s_{i,g} = 1$$

Derivation of wholesale market shares is similar to that of market shares described in equations (4a) and (4b) in the previous section, where market shares shift if net utility differs and switching costs dampen this process. Since a retailer is a trader rather than a consumer, we should think of utility in terms of profit. If retailer i were to buy all its energy from wholesaler g, this would yield a net profit of:

$$v_{i,g}^{R} = \sum_{s=1}^{6} n_s s_{is} \left(\left(p_{is} - p_{\tau s}^{d} \right) x_{is} + m_{is} - f_{is} - m_{\tau s}^{d} \right) - \sum_{s=1}^{6} n_s s_{is} \left(p_g^R x_{is} \right) - m_g - m_{\tau s}^{t} \quad (1')$$

As we noted earlier, retailers' demand is derived from their customers' demand. Using the shares defined above and denoting retailer parameters by superscript R, we may define:

$$x_g^R = \sum_{i=1}^{k} s_{i,g} \sum_{s} n_s s_{is} x_{is} \quad (3')$$

Although equation (3') looks very different from equation (3), the mechanism behind it is similar. To understand this, let us first turn to the purchase costs for retailers. Earlier we defined these costs as the wholesale price (p_g^R) plus transaction costs (pc_{is}^0), but we did not formalize this definition. Using the shares defined in this section, we may now define purchase costs for retailer i as:

$$pc_{is} = \sum_{g=1}^{l} s_{i,g}\, p_g^R + pc_{is}^0 \quad (7)$$

We perform a simple experiment to show the relationship between x_g^R and p_g^R. For simplicity we assume that all firms, both retailers and wholesalers, are symmetric. Furthermore, we assume that all wholesalers raise p_g^R by the same amount, for instance because costs have exogenously gone up. Because of the symmetry assumption, we know that $s_{i,g}$ does not depend on p_g^R, so we may write the first derivative of equation (3') with respect to p_g^R as:

$$\frac{\partial x_g^R}{\partial p_g^R} = \sum_{i=1}^{k} \frac{\partial x_g^R}{\partial x_{is}} \frac{\partial x_{is}}{\partial p_{is}} \frac{\partial p_{is}}{\partial p_g^R} = \sum_{i=1}^{k} s_{i,g} \frac{\partial x_{is}}{\partial p_{is}} 1 = \frac{\partial x_{is}}{\partial p_{is}}$$

which is also the first derivative of equation (3) from the previous section.[11]

[11] Dropping the assumption of symmetric firms will yield slightly different results. This does however not affect our main finding that the mechanisms behind equation (3') are similar to those behind equation (3).

As far as costs and profits are concerned, wholesalers delivering to retailers are treated like before. Since retailers may be considered to be very large users, this implies that equation (5") applies for costs, with similar adjustments to equation (6) for profit.

3.3 Transport of energy

Up to this point, we have described the process of trade in energy without wondering how traded energy would arrive at its destination. This section will shed some light on the transport of energy.[12] An energy transporter, whether it is a distributing company or a transmission grid operator, is obliged to grant traders access to its network. The network operator charges a uniform access fee per unit of energy transported, denoted by $p_{\tau s}^{d}$ for distribution and $p_{\tau s}^{t}$ for transmission, as well as a standing charge ($m_{\tau s}^{d}, m_{\tau s}^{t}$) per connection. Per unit transport costs (tc_d, respectively tc_t) are assumed to be constant and exogenous, as are connection dependent costs tf_d and tf_t. A typical distribution company therefore has a the following profit equation:

$$\pi_d = \sum_{s=1}^{13} n_s x_{ds}\left(p_{\tau s}^{d} - tc_d\right) + \sum_{s=1}^{13} n_s \left(m_{\tau s}^{d} - tf_d\right) \tag{8}$$

The profit equation for a transmission firm also follows from the previous sections:

$$\pi_d = \sum_{s=1}^{19} n_s x_{ts}\left(p_{\tau s}^{t} - tc_d\right) + \sum_{s=14}^{19} n_s \left(m_{\tau s}^{t} - tf_t\right) + \sum_{i=1}^{k} \left(m_{\tau s}^{t} - tf_t\right) \tag{8'}$$

We noted in the previous section that retailers' demand for wholesale energy was derived form demand by their customers. A similar mechanism holds for the demand for energy transport. A customer demands a certain amount of energy, that has to be transported. Therefore it is no surprise that the equation defining the demand for energy transport, resembles equation (3'):

$$x_{ds} = \sum_{i=1}^{k} s_{is} x_{is} + \sum_{g=1}^{l} s_{gs} x_{gs} \qquad \forall\, s < 14 \tag{9}$$

And similarly for a transmission company. Note that small users are also clients of the transmission company, as figure 2.1 and equation (3') suggest. Like with equation (3'), we can show that the mechanism behind equations (9) and (10) are similar to the mechanism behind

[12] We limit ourselves to the case where transporters are independent firms. The case where the transporter is also one of the traders is discussed in Lijesen (2001).

demand equation (3). Following the same steps as we did before, it can be shown that, under the assumption of symmetry:

$$\frac{\partial x_{ds}}{\partial p_{\tau s}^{d}} = \frac{\partial x_{is}}{\partial p_{is}}$$

The fact that transport firms are pure (regional) monopolists is recognized broadly and in almost any country regulation is set in place. We model this in a simple way, assuming binding regulation on all access fees. This implies that the access fees equal their exogenously determined regulated levels.[13]

[13] For a more extensive treatment of network regulation, see Newberry (2001)

4 Parameter values

Parameter values of the model are set to represent the Dutch energy retail and wholesale markets as precise as possible. An obvious problem here is that hardly any data relates to the post deregulation period. We distinguish between demand parameters and cost parameters. We will discuss the parameters according to this distinction in the following two sections. Section 4.3 is dedicated to a brief description of the influence on data quality on the validity of our model.

4.1 Demand parameters

Following demand model Nemo, we distinguish between 19 economic sectors. Nemo's sector classification closely follows that of the CBS's energy statistics, implying a low level of aggregation in energy-intensive sectors (for instance four different chemical sectors) and a higher level of aggregation in others. Households are also considered a sector, as is the transport activity (rather than the transport industry).

The model describes customers as individual actors, whereas data are sectoral. We define users in terms of 'household equivalents' (heq's). Each heq has an annual energy use of 3300 kWh of electricity and 1595 m^3 of natural gas, which is roughly the energy use of an average household in the Netherlands. Sector size is then defined as the number of heq's (n_s) and is determined as sectoral energy use divided by 3300 or 1595 for electricity and gas respectively. Note that sector size may differ between types of energy, except for households, for whom the actual number of 6.6 million is used. Sector size is also used to model exogenous demand growth.

The demand parameters in our model are derived from the elasticities used in Nemo. Given the definition of demand elasticities and our formulation of the demand function in equation (3), we may derive the value of parameter b_s from the elasticity, price and volume. Since the per unit price equals costs and volume is defined as the energy use of an average household, the value of b_s can be directly related to the demand elasticity.

$$\frac{\partial x_s}{\partial p_s} = \varepsilon_s \frac{x_s}{p_s} = -\frac{1}{b_s}$$

Given the value of parameter b_s, the other demand parameter, a_s, can also be derived from equation (3):

$$a_s = b_s x_{is} + p_{is}$$

Parameter Z_s is much harder to derive, since no data on switching behaviour are available yet. As we have seen in the model description however, Z_s is also a measure for the profit margin. Although profit margins are not reported either, we may use the cost estimations used in our model and confront them with the standing charges computed in the model. Standing charges are derived from average prices, as reported by CBS (2000) and per unit prices. Z_s-values are adjusted in a trial and error sequence, such that average prices according to the definition given in section 4.1 equal those in CBS (2000), given the cost-based per unit prices in our model.

Our estimate of parameter Z_s as described here may be biased for several reasons. First of all, we need to run the model with a single retailer in order to proxy the current situation. This implies that we use our oligopoly model to simulate a monopoly simulation. In itself this is not a problem, a monopolist competes with the zero net-utility option, which is exactly the way it is modeled here. Still, this may distort our estimate of Z_s, since the difference between an oligopoly and a monopoly contains more than the mere number of suppliers.

A second problem may be that utilities in the present and recent past are not profit-maximizers, implying that our model outcomes are inconsistent with their behavior. As we have noted in section 2.3, per unit retail prices have gone down, whereas standing charges have gone up, implying a development towards optimal two part pricing as described in our model. Our figures, most of which relate to the year 2000, have not fully captured this ongoing development however. This means that we will have to adjust figures as new data become available.

Another possible bias of Z_s may come from possible flaws in our cost estimates. If these flaws occur, our profit margin estimates will be inaccurate as well and Z_s will likewise be biased. Note however that our estimate of the standing charge, although based on inaccurate data, will still be consistent for the current situation.

Parameter $u_{is}{}^{\circ}$, reflecting the utility of being connected to provider i, is kept at zero value for al retailers in our model. It may later be used to express differences between retailers in quality, reputation, brand familiarity and so on.

Table 4.1	**demand parameters and variables, electricity**				
	n_s (millions)	a_s(€)	u_{is}°(€)	b_s	Z_s (€)
Horticulture	0.22	2.23	0	0.066	190
Other agriculture	0.26	2.75	0	0.081	190
Food, beverages, tobacco	1.58	0.99	0	0.028	190
Textile, clothing, leather	0.18	2.23	0	0.066	190
Paper, printing, publishing	0.82	2.23	0	0.066	190
Organic chemicals	1.42	2.23	0	0.066	190
Inorganic chemicals	0.66	6.57	0	0.197	190
Fertilizer	0.12	2.23	0	0.066	190
Other chemical	0.56	2.23	0	0.066	190
Iron and steel	0.62	2.23	0	0.066	190
Non-ferrous metals	1.87	6.57	0	0.197	190
Metal products	1.67	2.23	0	0.066	190
Building materials	0.48	2.23	0	0.066	190
Other industrial	0.81	2.23	0	0.066	190
Construction	0.23	2.75	0	0.081	190
Services	8.29	1.22	0	0.035	190
Government	0.94	1.68	0	0.048	190
Transport	0.52	2.23	0	0.066	190
Households	6.61	0.40	0	0.010	57

Table 4.2	**Demand parameters and variables, natural gas**				
	n_s (millions)	a_s(€)	u_{is}°(€)	b_s	Z_s (€)
Horticulture	2.15	4.59	0	0.0028	2000
Other agriculture	0.43	1.03	0	0.0006	66
Food, beverages, tobacco	1.69	4.59	0	0.0030	2000
Textile, clothing, leather	0.13	0.99	0	0.0006	2000
Paper, printing, publishing	0.60	4.59	0	0.0031	2000
Organic chemicals	1.37	9.09	0	0.0068	9000
Inorganic chemicals	0.12	9.09	0	0.0069	9000
Fertilizer	2.56	9.09	0	0.0068	9000
Other chemical	0.81	9.09	0	0.0048	9000
Iron and steel	0.28	9.09	0	0.0058	9000
Non-ferrous metals	0.09	9.09	0	0.0061	9000
Metal products	0.52	2.34	0	0.0015	2000
Building materials	0.56	4.59	0	0.0030	2000
Other industrial	0.11	4.59	0	0.0032	2000
Construction	0.08	5.61	0	0.0034	66
Services	2.67	1.03	0	0.0006	66
Government	0.38	0.96	0	0.0005	66
Transport	0,00	2.31	0	0.0015	66
Households	6.61	0.84	0	0.0004	132

4.2 Cost parameters

Access fees for transmission of electricity and distribution of both gas and electricity are regulated. Since energy transport is a monopoly and short term demand elasticities for energy are fairly small, we can safely assume that regulatory restrictions are binding. Therefore, we use regulated tariffs to reflect actual access fees.[14] The only access fee that is not explicitly regulated is the one for the transmission of gas. In Gasunie's annual report over 2000, 'other incomes' are reported to amount to € 88 million at a volume transported for third parties of 8 billion m^3. Using these figures and rounding the result downward since the 88 million is likely to contain some other types of income as well, we estimate gas transmission costs in our model at 1 euro cent per cubic meter.

Standing network charges are regulated, as well as standing retail charges for residential users. We assume that the current regulated standing charge allows for a margin of fifteen percent over fixed costs, which implies that fixed costs are at 1/1.15 of the regulated standing charge. Note that the fixed costs apply to heq's, as defined in section 4.1. This implies an implicit relation to (average) firm size, which reflects higher costs due to for instance higher complexity of billing and so on. Since this relation is likely to be less than proportionate with size, a lower value for very large users was applied in the calibration process in the case of electricity.

Hardly anything is known about variable costs of retail (pc^o in the model). Comparing end user prices with cost factors other than variable costs of retail suggests that, under the assumption that current prices are cost based, variable costs of retail are around half a euro cent per kWh for retail and next to zero for wholesale. Tables 4.3 and 4.4 report cost parameters for electricity and natural gas respectively.

[14] See http://www.nma-dte.nl/nl/besluiten/elektriciteit/transport/bat/bat.html (in Dutch).

Table 4.3 Cost parameters and variables, electricity

	tf(€/customer)	f(€/customer)	pc_o(€/kWh)	p_τ^d(€/kWh)	p_τ^t(€/kWh)
Horticulture	3.19	3.19	0.005	0.037	0.002
Other agriculture	3.19	3.19	0.005	0.037	0.002
Food, beverages, tobacco	1.5	1.5	0.005	0.037	0.002
Textile, clothing, leather	1.5	1.5	0.005	0.037	0.002
Paper, printing, publishing	1.5	1.5	0.005	0.037	0.002
Organic chemicals	1.5	1.5	0	-	0.002
Inorganic chemicals	1.5	1.5	0	-	0.002
Fertilizer	1.5	1.5	0	-	0.002
Other chemical	1.5	1.5	0	-	0.002
Iron and steel	1.5	1.5	0	-	0.002
Non-ferrous metals	1.5	1.5	0	-	0.002
Metal products	1.5	1.5	0.005	0.037	0.002
Building materials	1.5	1.5	0.005	0.037	0.002
Other industrial	1.5	1.5	0.005	0.037	0.002
Construction	6.39	6.39	0.005	0.037	0.002
Services	3.19	3.19	0.005	0.037	0.002
Government	3.19	3.19	0.005	0.037	0.002
Transport	1.5	1.5	0	-	0.002
Households	3.19	3.19	0.005	0.037	0.002

Table 4.4 Cost parameters and variables, natural gas

	tf(€/customer)	f(€/customer)	pc_o(€/m^3)	p_τ^d(€/m^3)	p_τ^t(€/m^3)
Horticulture	18.02	18.02	0	-	0.01
Other agriculture	17.94	17.94	0.003	0.02	0.01
Food, beverages, tobacco	18.02	18.02	0	0.02	0.01
Textile, clothing, leather	18.02	18.02	0	0.02	0.01
Paper, printing, publishing	18.02	18.02	0	0.02	0.01
Organic chemicals	18.02	18.02	0	-	0.01
Inorganic chemicals	18.02	18.02	0	-	0.01
Fertilizer	18.02	18.02	0	-	0.01
Other chemical	18.02	18.02	0	-	0.01
Iron and steel	18.02	18.02	0	-	0.01
Non-ferrous metals	18.02	18.02	0	-	0.01
Metal products	18.02	18.02	0	0.02	0.01
Building materials	18.02	18.02	0	0.02	0.01
Other industrial	18.02	18.02	0	0.02	0.01
Construction	17.94	17.94	0.003	0.02	0.01
Services	17.94	17.94	0.003	0.02	0.01
Government	17.94	17.94	0.003	0.02	0.01
Transport	17.94	17.94	0.003	0.02	0.01
Households	17.94	17.94	0.003	0.02	0.01

4.3 Data quality and validity of the model

As we noted earlier, hardly any data on the post deregulation period are available, since deregulation is either from a recent date or not implemented yet. This implies that many of our data sources relate to pre-deregulation periods. Two problems are associated with this aspect.

First, behavior prior to deregulation may differ from behavior after deregulation. Reasons behind such a deviation may be different goals for companies (provision of a 'public' good rather than profit maximization), the absence of competition (keeping in mind that the reward for monopoly is a quiet life) and current regulation.

A second problem relating to using pre-regulation data is that fundamental changes may affect parameter values. The value of switching costs with a real possibility to switch may well differ from the value of switching costs without that possibility.

Apart from the use of pre-regulation data, we did not differentiate our data between sectors too often out of sheer necessity. Although this is not a huge problem in terms of accuracy, it does diminish the level of detail for which separate robust outcomes are available.

The quality of the data used here is not as high as we would have liked. Although the model is capable of reconstructing the current situation, we think that data quality requires the results to be interpreted with caution. We do not have the illusion that a model calibrated on data of this quality will yield precise quantitative results. Rather we would like to think of our modeling results in terms of plausible directions.

5 Forecasts of end user prices

This section presents the results of numerical simulations made with the model described in earlier sections. Section 5.1 gives an outlook of the Dutch energy market to 2010, followed by several sensitivity analyses, showing the effects of a change in key assumptions, regarding the number of entrants, cost differences between retailers and the upper bound of switching costs.

5.1 Outlook to 2010

We use the model described in the previous sections to forecast end user energy prices in a liberalized energy market. General economic indicators that are exogenous to the model, such as GDP growth and inflation are taken from a recent medium term forecast of the Dutch economy.[15] We follow the distinction between a 'careful' and an 'optimistic' scenario used in that forecast. Commodity prices for electricity and gas follow from European supply models and are treated as exogenous here.[16] Table 5.1 lists the exogenous variables used in terms of average annual changes.

Table 5.1 Exogenous variables, 2003- 2010

	2003-2010 careful	optimistic
	average annual change in%	
Gross Domestic Product	2¼	2¾
Consumer price index	1¾	2
Natural gas commodity price		
- small users	−3	−2½
- medium and large users	−5	−4¼
Electricity commodity price		
- small users	0	¼
- medium and large users	0	¼

As we have seen in section 2, entry into retail market segments occurs after opening of those segments. We assume that entry in retail will likewise occur in 2004, when small users get free provider choice. Entry may either take the form of interregional competition between incumbents or of entry by new retailers. Regions with high customer densities are probably

[15] CPB (2002).

[16] See Kingma *et al.*, 2002 and Mannaerts *et al.*, 2002.

more attractive to retailers than regions with low density, so entry is likely to be concentrated in urbanised regions. We refrain from regional differences in our analysis however. Earlier experiences with market openings (green electricity, medium users, see section 2.5) show that the four large retailers enter each others markets. To account for the fact that some regions are less interesting for entrants, we adjust the number four downward. Our educated guess would be that the average region will see an increase from one to three retailers from 2004 on. For wholesale of electricity, we assume the same increase, whereas we assume that there will be no (domestic) entry in the wholesale market for natural gas. This reflects the powerful position of 'Gasunie'. Finally, we assume that network access fees at any level are effectively regulated at a nominally fixed level.

Energy use in the Netherlands is subject to a tax aimed at reducing energy use in order to keep emissions down. Energy taxes are degressive with respect to energy use, meaning that the marginal tax rate declines with volumes. In this system, large users also pay a lower average tax rate than smaller users. Average tax rates are computed using information from the Dutch Treasury Department on rates and firm size distributions. Taxes are determined using the value for 2001 as a base and then indexed against inflation for the following years.

We distinguish between average prices and unit prices in our outcomes. Unit prices correspond to variable p in our model, whereas average prices also incorporate the standing charge expressed in a price per unit of energy consumed. The average price may be expressed as:

$$p_i^a = p_i + \frac{m_i}{\hat{x}_i}$$

Where the hat denotes a base year value in order to prevent denominator effects to influence the outcome. Table 5.2 list the average annual changes in end user prices for small, medium and large users for gas and electricity.

Table 5.2 End-user prices for natural gas and electricity, 2003- 2010

	2003-2010 careful	optimistic
	average annual change in%	
Natural gas, unit price		
- small users	–½	–¼
- medium users	–3	–2½
- large users	–4	–3
Natural gas, average price		
- small users	–1½	–1¼
- medium users	–3	–2½
- large users	–3¾	–3
Electricity, unit price		
- small users	¾	¾
- medium users	¼	½
- large users	¼	¼
Electricity, average price		
- small users	–1¾	–1¾
- medium users	¼	½
- large users	¼	¼

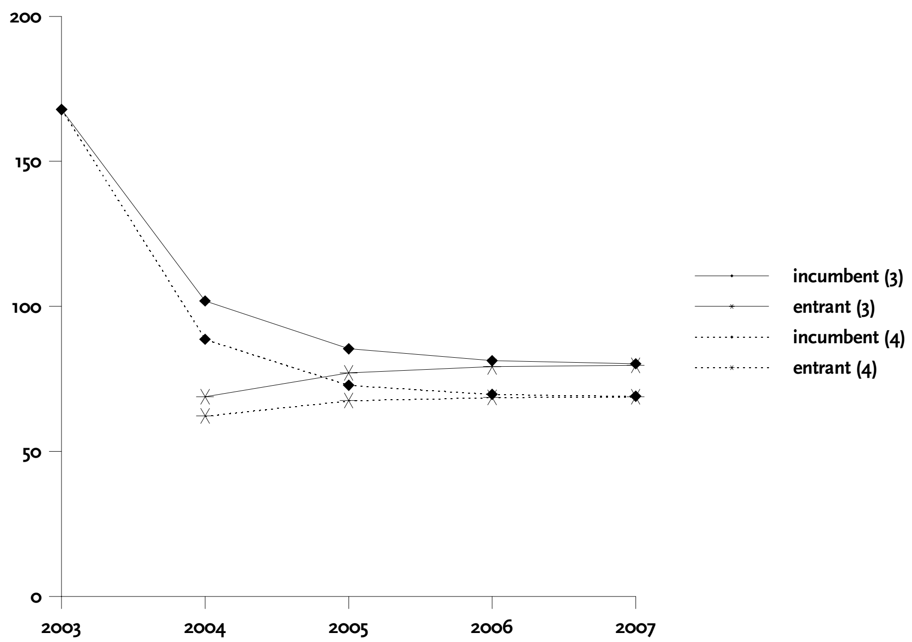
Table 5.2 shows that per unit prices in general follow the developments of commodity prices as presented in table 5.1. The effect of lowered gas commodity prices is dampened somewhat by fixed factors in the end user price as well as by a modest increase (indexation) of energy taxes. The increase in energy taxes also leads to a slight increase of per unit electricity prices relative to their commodity prices.

The difference between per unit and average prices is most important in the case of small users. For these groups, the standing charge is relatively important in the average price. In the case of electricity, declining standing charges even lead to a decrease in the average price, whereas the per unit price increases.

5.2 Effect of an extra entrant

To illustrate the effect of entry on modelling outcomes, we adjust the base scenario presented above by adding an extra entrant. As we have seen in the previous chapter, the effect of increased competition materializes in the standing charge. Figure 5.1 graphs the effect of an extra entrant on the standing charges of the incumbent and the representative entrant for natural gas.

Figure 5.1 Development of standing charges (€ per customer) for different levels of entry, natural gas



Before we discuss the effects of an extra entrant, let us first shed some light on the effect of entry in 2004 (solid lines). New retailers enter at a low standing charge in order to gain market share, whereas the incumbent uses its favourable position (market share of 100% in the previous period) to extract rents. Entry forces the incumbent to lower its standing charge, and the loss of market share erodes its favourable position, leading to a further decline of the incumbent's standing charge. The entrants on the other hand raise their standing charges as they gain market share, since the need for aggressive pricing lessens. Three years after entry, the market stabilises at equal standing charges.

The effect of an extra entrant is shown by the dashed lines. Standing charges are lower from the first day of entry on, because competition is more intense between four firms than it would have been between three. A graph of market shares would look very similar with the share of the incumbent falling from 100 percent in 2003 to the inverse of the number of retailers in 2007 and the shares of the entrants rising from nothing to the same value. Per unit prices are unaffected and average prices fall as the standing charge goes down. Likewise, industry profit declines.

5.3 Impact of cost differences

We illustrate the impact of a difference in cost by assuming that one of the entrants in the natural gas retail market has no fixed costs (€0 per customer instead of €17.94). The magnitude of the cost difference is obviously exaggerated to gain insight in the mechanism. Figure 5.2 plots the development of both standing charges and market shares under this assumption.

Figure 5.2 Development of standing charges (€/customer, left axis, solid lines) and market shares (fractions, right axis, dashed lines) if entrants have different fixed costs, natural gas

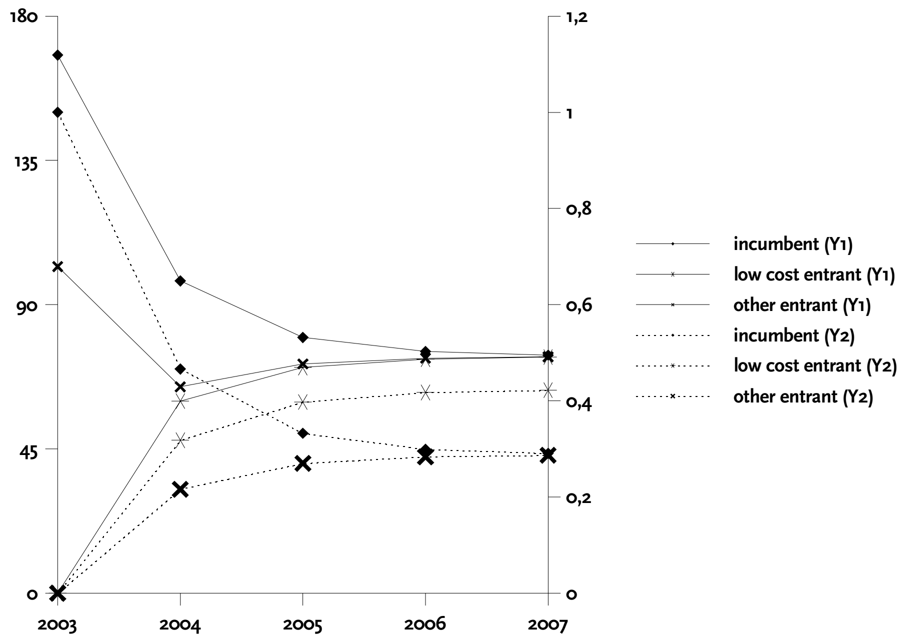


Figure 5.2 shows that the no-cost incumbent enters at a lower standing charge than the other entrant, thus immediately realising a higher market share. In 2007, after the outcomes have stabilised, the low cost firm has a higher market share than the other retailers, whereas the standing charges have converged. Note that standing charges are at a lower level than in the three-firm market in figure 5.1. The low cost firm has passed part of its cost advantage on to consumers, forcing its opponents to lower their standing charges as well. The difference with the standing charge in the base outcomes is exactly the cost difference divided by the number of suppliers, which is a familiar outcome for oligopoly models with cost differences.

It may seem odd that the lower cost firm has a higher market shares while prices are equal. The explanation for this phenomenon is that the low cost entrant gained market share through a low standing charge in the early years. As the outcomes have stabilized, none of the competitors can rationally undercut the low cost firm's standing charge. This implies that prices are equal for all firms and customers have no incentive to switch suppliers, thus stabilizing market shares at their unequal level.

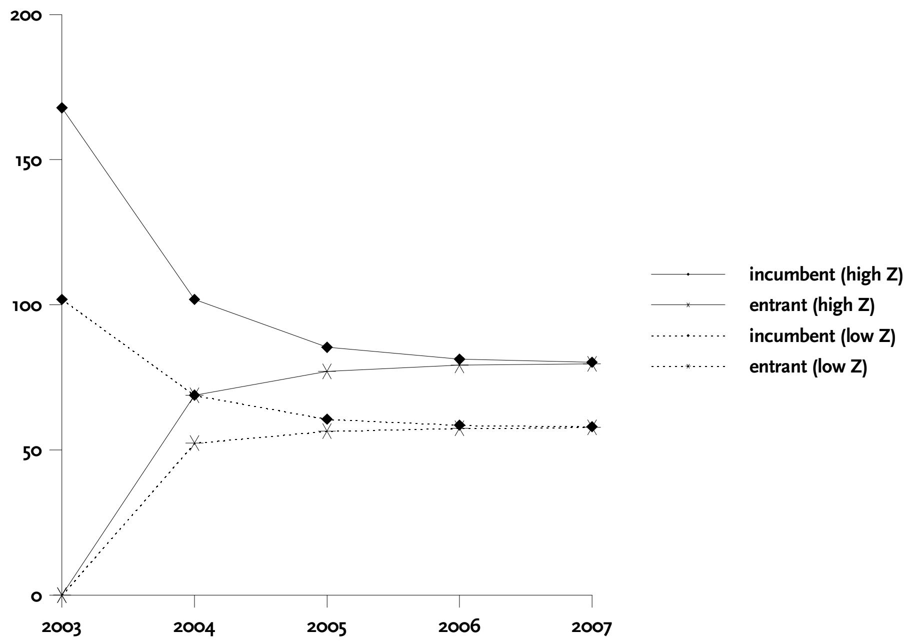
With per unit prices unaffected and a lower standing charge, we arrive at lower average prices, much like the outcomes in the previous case. This time however, industry profit increases. The profit per customer for the incumbent and the 'other' entrant are one third of the cost advantage lower in comparison to the base case. The profit per customer for the low cost entrant is two thirds times the cost advantage higher than in the base case. At the same time, the market share of the most profitable firm is higher than in the base case, yielding a higher average profit per customer. Since the total number of customers is fixed, this implies that industry profits have gone up.

If the cost advantage were in variable rather than fixed costs, the main mechanisms would have applied, with a few differences. Again, the low cost firm would have gained a higher market share. The low cost firm would have raised its standing charge as well and it would have done so up to the point where the utility loss of higher standing charge would have offset the combined utility gains from a lower unit price and higher consumption. Again, both consumers' utility and industry profits would have gone up.

5.4 Lower switching costs

In this section, we illustrate the importance of switching costs in our model, by assuming that they are halved. Such a decrease may occur in practice because of increasing information on available alternatives. Figure 5.3 illustrates the effects of this assumption on the standing charge for small natural gas users.

Figure 5.3 Development of standing charges for different levels of switching costs, natural gas



The figure shows that lower switching costs lead to lower standing charges. Since costs are unchanged, this implies lower profits as well, which is consistent with findings of Klemperer (1987), Green (2000) and De Bijl (2000), as reported in section 2.

Two other interesting findings follow from figure 5.3. First of all, monopoly profits (prior to entry) are also lower, implying that switching costs affect profits even if switching is impossible. This is obviously not in line with logic, but an alternative interpretation might be that the monopolist tunes down a bit in fear of future switching. The second finding that follows from figure 5.3 is that lowering switching costs does *not* speed up switching: the outcomes do not stabilize sooner. The reason for this phenomenon is that producers take the switching costs into account in their pricing decisions.

5.5 Other variations

Apart from the variations mentioned in the previous sections, one can think of several others. In this section, we briefly discuss them.

If costs change for all retailers at the same time, they will simply pass on the change to consumers, no matter whether the change involves fixed or per unit costs. This notion is important for energy taxation, which boils down to an over the board increase of per unit costs. It can easily be checked from the model that it is irrational for retailers to react on symmetric shifts.

An autonomous increase in demand will not have any effect either for the same reasons. The increase will however affect commodity prices through an increase in scarcity.

6 Conclusions

The introduction of competition in energy retail markets is likely to lead to lower standing charges, bringing total costs for energy users down. Per unit prices follow developments in commodity prices and energy taxes. As both energy taxes and electricity commodity prices are expected to rise, the end user price for electricity will rise as well. Per unit natural gas prices will decline due to a decrease in natural gas commodity prices.

The validity of our model outcomes is however uncertain, since data quality may be poor. Our model describes a situation that does not exist yet, implying that some data can not be derived adequately. This implies that our forecasting results reflect plausible directions rather than precise values.

Sensitivity analyses show that the effect of increasing competition may be strengthened if the number of entrants increases. One extra entrant decrease the standing charge by 10 Euros per customer per year in the end year of our analysis. This boils down to less than ¼ percentage point of annual mutations of average prices for households, which is the most sensitive group in this respect.

Likewise, entry of low cost competitors will increase the impact of competition and lower standing charges. The effect of lower costs of a variant where one retailer has no fixed costs per customer at all, is lower than the effect of an entrant as described above, implying that our model is fairly insensitive to this variable. Obviously, as the number of low cost retailers increases, the impact on outcomes also increases.

Lower switching costs are also associated with tighter competition and therefore lower prices. If we lower the switching costs in our model substantially, by halving the upper bound of the calibrated value, the level of the standing charge would be considerably lower throughout the period of our analysis. It would however also flatten the development over time, lowering our annual mutation of average price of natural gas for households by nearly ½ percentage point.

Future research should first and foremost be aimed at improving data quality. This includes both recalibration as data becomes available and expansion to a multiple region model. The latter allows for regional differences and allows us to model regional transport restrictions and their impact on prices.

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Annex I derivation of market shares

In this annex, we derive the equations for market shares of retailers in our model. For notational simplicity, we omit sector subscripts s. We start by solving the equation for the duopoly case. Recall that the representative customer will switch from provider i to provider j if $v_i < v_j - z$, where z is distributed uniformly on the interval [0, $Z_{si,\ t-1}$]. Without loss of generality we assume that $v_i < v_j$. Consumer g is indifferent between staying with firm i and switching to provider j if $v_i = v_j - z^g$. This implies that any customer of firm i with lower switching costs (i.e. $0 < z < z^g$) will switch to firm j. Conversely, customers of firm i with higher switching costs (i.e. $z^g < z < Zs_{i,t-1}$) will stay. The fraction of customers that will stay with firm i equals $\left(Zs_{i,t-1} - z^g\right) / Zs_{i,t-1}$, whereas the fraction of firm i's customers that will switch to firm j equals $z^g / Zs_{i,t-1}$. The market share of firm i in period t equals the market share in the previous period times the fraction of customers that stay. Now we find that:

$$s_{i,t} = s_{i,t-1} \frac{Zs_{i,t-1} - z^g}{Zs_{i,t-1}} \tag{A.1}$$

or:

$$s_{i,t} = s_{i,t-1} - s_{i,t-1} \frac{z^g}{Zs_{i,t-1}} = s_{i,t-1} - \frac{z^g}{Z} \tag{A.1'}$$

which we may rewrite to:

$$s_{i,t} = s_{i,t-1} + \frac{v_i - v_j}{Z} \tag{A.1''}$$

Next, we expand our analysis to a market with three firms, i, j and k. We assume that $v_i < v_j < v_k$. Again, consumer g is indifferent between staying with firm i and switching to firm j if $v_i = v_j - z^g$. Furthermore, firm i's customer h is indifferent between switching to firm k and not switching if $v_i = v_k - z^h$. Since $v_j < v_k$ (and therefore $z^h > z^g$), any customer willing to switch from firm i to firm j, is better off switching from firm i to firm k instead. This implies that any customer of firm i with switching costs below z^h will switch to firm k, whereas all other consumers of firm i will stay. Note that no consumers switch to firm j, which implies that intermediate firms have no influence, so that we may generalize the result by stating that $z^h = \max(v_k - v_i) = \max(v_k) - v_i$. Applying this to the duopoly solution, we may now write:

$$s_{i,t} = s_{i,t-1} + \frac{v_i - \max(v_j)}{Z} \tag{A.2}$$

for all firms that lose customers. These firms lose customers to the same firm, for notational simplicity assumed to be firm 1 for now, allowing us to describe the 'winning' firm's market share by:

$$s_{1,t} = s_{1,t-1} + \sum_{j=2}^{k} s_{j,t-1} - s_{j,t} \qquad \text{(A.3)}$$

Substituting (A.2) into (A.3) yields:

$$s_{1,t} = s_{1,t-1} + \sum_{j=2}^{k} \frac{v_1 - v_j}{Z} \qquad \text{(A.3')}$$

Since $v_1 = v_1$, we may drop the assumption that firm 1 is the 'winner' and generalize (A.3') to:

$$s_{i,t} = s_{i,t-1} + \sum_{j=1}^{k} \frac{v_i - v_j}{Z} \qquad \text{(A.3'')}$$

Note that in duopoly, both (A.2) and (A.3") simplify to (A.1").