Being in Balance: Economic Efficiency in the Dutch Power Market

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In this paper, we examine economic efficiency in the Dutch power market, an important pillar for successful creation of a competitive and non-discriminatory free power market. We examine historical time series of prices and volumes on the Dutch balancing market where energy companies are obliged to offer reserve capacity in order to offset power surpluses and deficits on the grid. We argue that these balancing prices and volumes are indicators for the level of economic efficiency. We find evidence that the level of economic efficiency has increased in the Dutch power market while the level of security of supply has maintained.

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1 Introduction

The European electricity market is currently undergoing a liberalization process that should be finalised in most of the EU member states before January 2005. The ultimate objective of this process, as documented by the European Parliament a decade ago in the 96/92 Directive, is the creation of an internal competitive European electricity market. This complex trajectory can only be completed when efficiency increases in the power supply chain are accomplished, while safeguarding security of supply.[1] In addition, it necessitates severe reforms, such as allocative changes in property rights, for national regulatory authorities, network and transmission operators, the power producers, wholesalers, consumers and other market participants in each member state.

The continuing academic debate in liberalisation and privatisation theory, regarding industries that are of vital importance for the social welfare in an economy and involve public goods, such as the gas and electricity sector, centres around the proper level of government regulation in a market economy and the level of efficiency gains achieved, by the choice of governance structure.[2] The reasoning used in social welfare economics is that competition leads to economic efficiency that maximizing social welfare is the prime objective, and the mentioned debate should be based on these efficiency grounds. Being successful in achieving this goal in the electricity industry depends on the way the reforms are implemented. Existence of well-developed competitive wholesale markets is a must, as market participants need to underpin competitive offering to their clients. This became clear from the lessons learned from the California wholesale power supply crisis of 1999 and the power blackouts of early August 2003 in the United States and Canada, that left more than two million citizens in Detroit, New York and Toronto in the dark.

Motivated for reasons discussed above we examine to what extent recent Dutch power reforms have led to an increase in economic efficiency while maintaining the level of supply security. The Dutch Ministry of Economic Affairs has formulated a policy to achieve both economic efficiency and security of supply[3] and appointed a committee that monitors the performance of the wholesale electricity market on these indicators.

The Dutch wholesale day-ahead power market, established in 1999, is well developed in terms of liquidity[4]. In addition to this spot market, a real-time balancing market exists (a pioneering role in

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[1] Directive 96/92/EC (1997) and 03/54/EC (2003)
[2] For an overview of recent empirical privatisation and liberalisation studies, see Megginson and Metter (2001).
[3] See Energy Report (2002).
[4] See Newbery et al (2003) and EnergieNed (2003).

Europe) since 2001. On this market, residual capacity is traded on a 15 minutes basis. Based on economic theory we argue that prices and volumes on this market can be interpreted as indicators of economic efficiency and security of supply. We examine historical time series of prices and volumes to test hypotheses on the development of economic efficiency and security of supply. The measure that we present is an easy to implement alternative for monitoring efficiency, which is often constrained by data validity, reliability and availability.

Interpreting the results based on prices and volumes of the balancing market, we find evidence of increased economic efficiency while maintaining the level of security of supply in the Dutch power market. This result provides at least partial evidence of a successful liberalisation process of the Dutch electricity market.

The paper is structured as follows. In section 2 we discuss the primary objectives of electricity market liberalisation, formulated by the European Parliament and Council in several Directives European Community Electricity legislation acts and effectuated in the Dutch 1998 Electricity Law, in light of social welfare theory. In particular, we discuss the concepts of economic efficiency and continuity of supply that exist in the economic literature. Section 3 focuses on the developments in the Dutch wholesale market structure. Section 4 focuses on the role of the balancing market in achieving economic efficiency and security of supply. We formulate and empirically test hypotheses for the level of the economic efficiency and continuity of supply. Section 5 concludes.

2 Efficiency and security of supply

The 96/92/EC Directive concerning the creation of an internal gas and electricity market in the EU, which has been effective since December 1996, is the blueprint of the current ongoing market liberalisation trajectory. In this paper we focus on two important pillars of the successful creation of a competitive and non-discriminatory free energy market, which are described in note 4 of the Directive in the following context:

> *"Establishment of the internal market in electricity is particularly important in order to increase efficiency in the production, transmission and distribution of this product, while reinforcing security of supply and the competitiveness of the European economy and respecting environmental protection."*

Increased efficiency and the continuity of security of supply are key concepts, that should safeguard us from social-economic disasters, such as the Californian market liberalisation process that eventually resulted in a power crisis of 1999, which affected millions of households directly in their way of living.

The European Commission has recognised the need for a framework to monitor the performance made throughout the liberalisation process with respect to the objectives formulated. From an early stage, the special European committee EG DG TREN is responsible for the design of a monitoring system, in which several indicators are identified that should provide information about the developments made with respect to efficiency and security of supply. Since 2000, they have published an annual report that is based on information from the EU Member States. However, a closer look at these benchmark reports learns that the quality of the report has suffered from a lack of data and lack of harmonisation between existing data in the Member state countries. This makes it difficult to develop a sound monitoring framework that is needed to evaluate the success of European power liberalisation in terms of efficiency and security of supply.

In order to construct testable hypotheses we first focus on the academic proceedings on economic efficiency and security of supply.

Economic Efficiency

In the Energy report published by the Dutch Ministry of Economic Affairs (MEA) the increase of economic efficiency is a central goal in the creation of an internal market. The report states that freedom of choice for both suppliers and consumers is an important incentive to achieve economic efficiency, which should ultimately lead to a better price-quality ratio. An important indicator that is identified by the MEA for economic efficiency is the day-ahead price on the Amsterdam Power Exchange (APX). On the APX, traded volume has increased each year and prices have declined (Energy Report, 2002). Especially, wholesale consumers have benefited from more attractive prices.

The Dutch federation of energy distribution companies, EnergieNed, reports another indicator for efficiency: the level of reserve capacity (EnergieNed 2003). According to EnergieNed, a decline in the level of reserve capacity (up to a minimum emergency level) due to improved allocative efficiency should lead to benefits for the electricity market.

Welfare economics deals with the efficient use of resources and questions whether the market allocates resources among their competing users such that maximum welfare is reached. Two types of economic efficiency concepts can be distinguished:

First, the neoclassical theory on productive efficiency is large and includes the works from Harberger (1954) and Farrell (1957) among others. Firms are assumed to be internally efficient and produce maximum output for a given set of input variables and therefore minimise production costs. In particular, Farrell distinguishes two sources of productive efficiency: technical and allocative efficiency. Firms are assumed to be technical inefficient when they use more inputs than needed for a certain amount of output (thus efficient when a certain capital-labour combination is on the best-practice isoquant). Allocative efficiency grasps the inefficiency arising from technical efficient capital-labour combinations given input prices. This type of efficiency is reached when the value that consumers place on a good or service (reflected in the price they are willing to pay) equals the production cost, hereby statisfying the condition that the price equals the marginal cost.

A particularly interesting empirical study in the field of energy economics that deals with these issues is the work of Pollitt (1995), who employs four applicable econometric techniques to estimate the cost efficiency gains resulting from the privatisation process in the electricity supply industries of fourteen countries. He finds that while privatisation of power generation might lead to cost decreases, the same cannot be concluded from the power transmission and power distribution functions.

Second, Leibenstein (1966) argues that the empirical findings of allocative gains in the neoclassical studies are marginal compared to the efficiency gains from a difference source that he found in his study, which he called X-efficiency gains. This type of efficiency is rooted in the internal operation of the firm. Leibenstein (1966) claims that substantial gains in efficiency stem from sources such as motivation of decision-makers within the firm to use inputs optimally, and reorganization of materials handling (other than allocative inefficiency sources). For instance, Button and Weyman-Jones (1992) mention that nuclear-based power generators offer more prestige to management than gas-based power plants. This would typically not be recognized as an indicator for efficiency in the neoclassical stream.

The theoretical stream of X-efficiency following Leibenstein's lead focuses on behavioural decision-making efficiency gains and offer little measurement guidance. Also this stream has become a respectable discipline in applied economics.[5]

For the purposes of this paper it is sufficient to know that both productive efficiency and X-efficiency are both concepts for economic efficiency, but are based on different theoretical grounds as discussed above.

In this respect, the study of Boles De Boer and Evans (1996) is worth mentioning. They examine the economic efficiency in a welfare equilibrium framework of the deregulated telecom market (like electricity a public utility) in New Zealand. They postulate a welfare function that consists of a consumer surplus component and a producer surplus component, respectively reflecting gains from reduced observed prices and increasing productivity and demand. Their analysis also captures cost reductions. They estimate the total factor productivity growth (they focus on changes in network productivity from the liberalisation onwards), or as they call it X-efficiency, in the telecom reforms as the difference between output and input growth, both in terms of material, labour and capital indices. Issues of shortcomings that come to surface in this study are: (1) A lack of available and reliable data. For

[5] Important developments in this field, including those studies that focus on empirical measurement issues of X-efficiency and the relation with ownership structure and the institutional organization, are discussed in detail by Frantz (1988) and in a special section in the American Economic Review (1992) volume 82 (no 2) edition, which is called "X-inefficiency after a quarter of a century".

instance, unreliable producer's price indices needed to place expenditures on inputs and measure the capital index (e.g. material inputs) leads to understating of material and input figures, hereby affecting the interpretation of total productivity growth. (2) Questionable validity of empirical results because Boles De Boer and Evans do not measure improvement in X-efficiency (e.g. no output quality figures are included). The authors recognize the problems of an empirical economic efficiency study (in an industry similar to the power industry) associated with validity, reliability and availability. They stated explicitly to interpret the concluding result that price reductions transferred production surplus to consumer surplus (not compensated to the full extent by production gains and output expansion) with caution.

Another interesting empirical study that closely relates to economic efficiency in the electricity industry is the paper of Wolfram (1999). She examines the generators cost-price mark-ups in the deregulated British power market of the 1990s and uses direct measures of marginal costs that directly reflect the market power in the industry. She finds that generators charge prices that are significantly higher than the marginal costs but not up to the level that one would predict from standard oligopoly theory.[6] Wolfram states that they have not fully benefited from the inelastic demand and she suggests that this is caused by strategic behaviour to deter entry of a potential entrant.

When reviewing the literature we conclude that even when we identify indicators, such as the marginal cost function of a power generator, which are known to be highly dependent on the raw materials used, (in particular the fuel price and conversion efficiency (Wolfram, 1999) curve, the level of reserve capacity or power price levels, to monitor economic efficiency in the electricity industry) we can come across major difficulties. These vary from ordinary measurement problems to validity issues that bound an empirical study on economic efficiency. In section 4 we formulate a simple measure for allocative efficiency that uses prices and volumes on the balancing market to monitor economic efficiency gains. This is the market to trade power when the amount of net power on the grid is off balance, and according to EnergieNed (2003), substantial efficiency gains can be obtained by reducing the amount of reserve capacity, in such a way that security of supply is still guaranteed.

Security of Supply

Following the Dutch Ministry of Economic Affairs and EnergieNed the following aspects cover the security of supply concept in a liberalised market: (1) long-term availability of primary fuel supply and (2) security of a reliable power generation and distribution chain. EnergieNed concludes that on these

[6] In particular from the Cournot model, which is an oligopoly framework, in which a firm takes the output of the other firm(s) as given when determining its own profit-maximization strategy. The Cournot equilibrium is a special case of the Nash equilibrium. Green and Newbery (1992) also include the Cournot framework in their industrial economics analysis of the deregulated British power industry.

aspects The Netherlands perform very well, compared to other EU member states. Ad (1): The power portfolio-mix is well diversified. 55% of total Dutch electricity consumption in 2001 relies on the Dutch gas reserve area, which (currently, and most probably for the coming decades,) represents by far the largest gas reserves in the EU. Another 22% of consumption was obtained from heat power generators and about 20% is imported from Germany, Belgium and France. Ad (2): the Netherlands had the lowest number of power fall-out minutes in Europe. The new legislation to ensure proper capacity investments (competitive quality reward system) has been implemented in 2004, so it is too early to see if this high quality level can be maintained. EnergieNed states that the lack of legislation regarding reserve (or emergency) capacity gives rise for concern in near future. It is therefore too early to make final conclusions because the liberalisation process is still ongoing.

Van Werven and Scheepers (2004) define security of supply as the extent of continuity of power supply on mid-long term (two to seven years), determined by investments in production capacity, electricity consumption and its demand-supply matching mechanism. Based on these three categories they further make a distinction in ex-post versus ex-ante (short-term and mid-long-term) indicators in their design of a monitor matrix. They claim that the quality of monitoring the level of security of supply should be preferably based on (a selection of) the set of indicators that they have identified, which may lead to new insights in the current level of security of supply and in near future (e.g. such the probability on fall outs). They identify a set of indicators and rank them along the earlier mentioned criteria, namely validity (does a change in an indicator automatically imply a change in the security of supply), availability and reliability of the required data, and the signalling value (indicator should preferable provide insights two to seven years ahead, so that extension of capacity can be realised). Before the liberalisation process it was sufficient to focus on the supply-side: the installed production capacity and (investments in) the power infrastructure were the factors to monitor. Now the liberalisation process made the client and his/her needs more important in the process, which leads to a more demand-supply matching based than a supply planning-based consumption process/pricing mechanism.

Besides the traditional reserve capacity indicator, other key indicators to monitor are power prices quoted on the APX and the balancing market, contracts such as forward contracts (prices and volumes), import contracts (volumes) and ad-hoc foreign exchange. Van Werven and Scheepers (2004) conclude that of these six indicators, the balancing volumes on both the balancing and APX market score on average particularly well on the validity, availability and reliability criteria; respectively number 1 and 3 on their short-list of demand-supply matching indicators. Only the mid-long term signalling value of the balancing market is negligible compared to long-term forward and import contracts.

They argue that a declining trend in balancing volumes is an indicator for the need for investments in power facilities to produce excess capacity in order to guarantee security of supply in future. Also the earlier mentioned statement of EnergieNed (2003) about a declining trend in reserve capacity (which is typically traded at the balancing market as is discussed in section 3) up to a minimum amount of residual capacity to prevent power deficiencies identifies the balancing volumes as a proxy for continuity of supply. In the next section we will examine more closely the Dutch wholesale power markets, and in particular the balancing market.

3 The Dutch Wholesale Power Markets

The traditional cooperative agreements from 1971 between four state-owned production companies were further intensified in the 1986 OVS agreement. According to this agreement the companies are responsible for a close cooperation on production, generation and distributional activities, which essentially implies that security of supply should be guaranteed in a closed system of supply and cost pooling (of production and import costs) between these companies. This cost-pooled based system resulted in standard prices that were equally charged to all local distributional companies. This agreement was incorporated in the 1989 Electricity Law. When the Dutch government effectuated the 1998 Electricity Act (that replaced the 1989 Electricity Law), the first step to a free internal market was taken, as described in the 96/92/EG Directive and in its successive legal act 2003/54/EG. This starting point of the liberalisation process led to several reforms in the wholesale market, which are illustrated in figure 1.

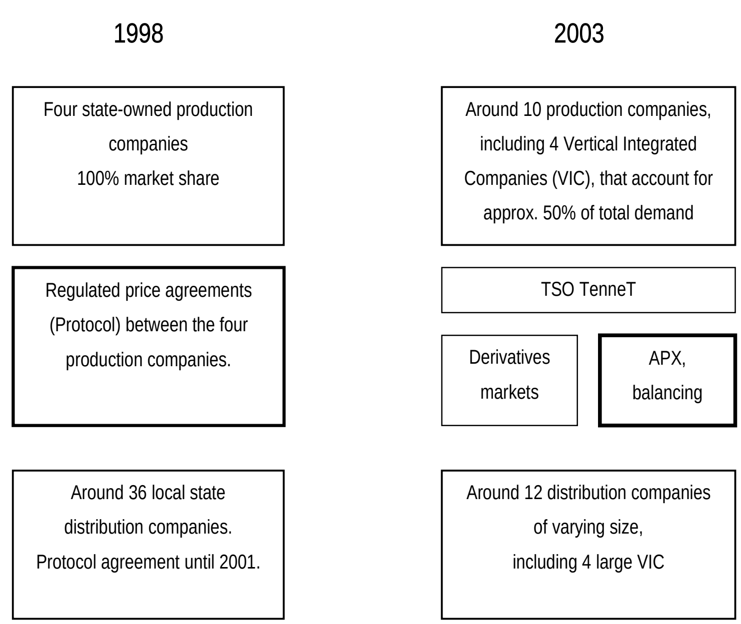

Figure 1 Dutch liberalisation reforms from 1998-2003

Source: EnergieNed (2003), Newbery et al (2003)

To ensure that a competitive internal market would be established, in which prices are determined by supply and demand, and that economic efficiency and continuity of supply would be guaranteed, TenneT has been established. TenneT, the national independent transmission system operator, is responsible for the national grid that connects both to the regional and European grids. TenneT monitors the reliability (e.g. maintenance) and continuity of the electricity supply. In 2001, TenneT acquired the Amsterdam Power Exchange (APX), the day ahead spot power market that was established two years before. At the same time, TenneT established the within day balancing market to ensure grid balance.

The Balancing market

On this market, program-responsible (PR) companies with more than 60 MW of capacity[7], who supply power to and consume power from the grid network, are obliged to offer reserve capacity to the balancing market. TenneT manages power flows on the grid and actively responds to possible total power deficit or surplus positions on a 15 minutes basis. In cases of balancing deficits, PR companies balancing reserve capacity offer price quotes to TenneT. TenneT purchases the volume needed against the best prices. The price of this balancing volume is charged to the PR that caused the deficit the day after. In cases of balancing surpluses, TenneT sells power to PR companies against quoted ask prices. Therefore, TenneT reports two balancing prices, one price for volume deficits and one for power surpluses. Table 1 presents summary statistics of balancing prices and volumes on the Dutch market.

Table 1 Summary statistics of balancing prices and volumes

	Price (€ / MWh)		Volumes (MW)			
	Surplus	Deficit	Surplus	Deficit	Absolute unbalance	Net unbalance
Mean	4.244	82.29	48.33	61.46	109.8	13.13
Median	7.150	45.45	40.24	54.16	97.25	12.53
Std deviation	38.19	113.3	36.31	38.81	62.36	41.95
Minimum	-222.0	-100.0	0.005	0.019	19.02	-327.3
Maximum	1754	1984	583.2	574.1	1106	405.5
Skewness	9.449	6.591	3.695	3.696	5.023	0.333
Kurtosis	370.8	77.80	31.05	29.72	51.61	9.808

Absolute unbalance is the sum of the surplus and deficit volumes. Net balance is the difference between deficit and surplus volumes. The data consists 70080 observations of 15 minutes observations from January 1st 2002 to December 31st 2003 obtained from the TenneT website (www.tennet.nl).

7 Since March 2004 also generators with more than 5 MW capacity are legally obliged to report their excess capacity to TenneT.

The table shows that on average the surplus prices are lower than the deficit prices. In cases of power deficit, TenneT purchases on average against a price of 82 euro, whereas it sells in cases of surplus against 4 euro. The standard deviation of the price levels equals 38 in cases of surpluses and 113 in cases of deficit. Note that negative prices exist as can seen from the minimum price levels. This is due to the fact that PR companies have to pay large fees for serious surpluses or deficits. They are willing to pay any price below the fee level to overcome paying the fee. The average surplus volume is lower than the average deficit volume, which leads to an average net positive unbalance.

4 Empirical analysis of efficiency and security of supply

In this section, we focus on the economic efficiency of the Dutch power market. Inferring information from dynamics of the unbalance prices and volumes, we test several hypotheses that relate to efficiency and security of supply.

Allocative efficiency

If a market becomes more allocative efficient, the merit-order on the day-ahead market implies that the cheaper generation facilities generate most of the consumption needed. From standard oligopoly theory we can expect that the power consumer can benefit from lower prices that are caused by the reforms illustrated in figure 1. The price level is expected to move closer to the efficient point (where prices equal marginal costs), and will typically lie between the monopoly and competitive price level. However, these prices might not reflect allocative efficiency, because of strategic pricing behaviour of market participants as pointed out by Wolfram (1999).

Balancing volumes are traded on the unbalance market that operates on the day of delivery, thus after the day ahead market. In allocative efficient markets, the unbalance deficit volume, i.e. the volumes needed to overcome shortages, should come from the more expensive production facilities as the cheaper one already operate fully due to the merit order of the day ahead market. If the Dutch power market becomes more allocative efficient, then we expect the deficit prices on the balancing market to show an upward trend as the more expensive generators are allocated to deliver electricity via the balancing market, in case unexpected demand does occur.

In figure 2 we have illustrated this hypothesis and how the liberalisation reforms resulted in a change in the way the market allocates resources among their competing uses. For simplicity we assume that the Dutch wholesale market consists of only cheap power generators (G1) and more expensive power generators (G2). In figure 2a we see that, prior to the reforms, allocation was based on the fuel diversification principle[8] (reflected in the utility rate) and prices were regulated (monopolistic behaviour), hence independent from base or peak demand.

From figure 2b we observe that in the oligopoly framework the output level is determined by the intersection of the marginal cost curve, with an upward slope reflecting the merit-order, and the marginal revenue function. The corresponding price is derived from the intersection of the derived output quantity with the demand curve. In this case prices are dependent on (the demand elasticity of) base or peak demand.

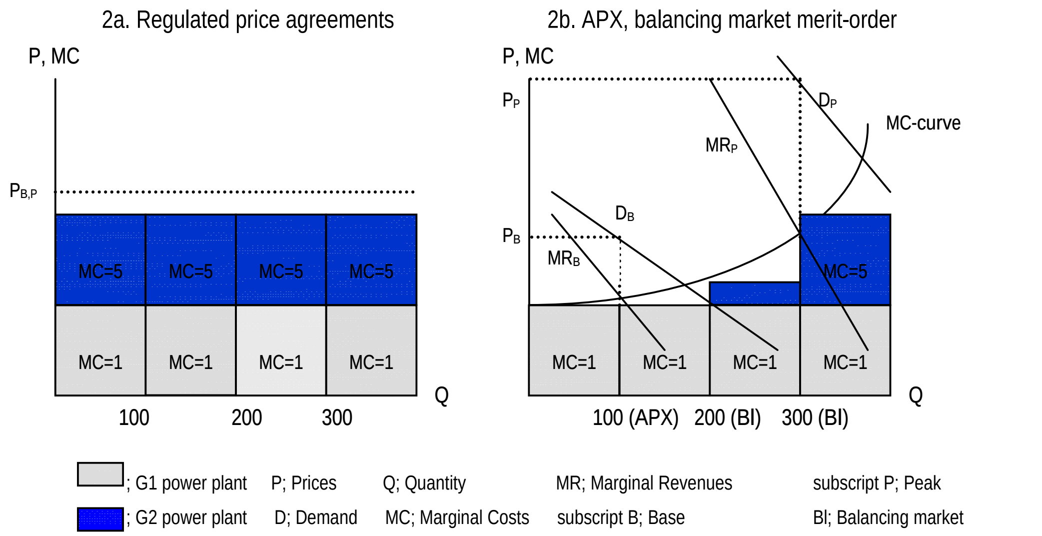

Figure 2 Dutch allocation mechanisms from 1998-2003 (corresponding with bold blocks of figure 1)

From figure 2b we see that if the Dutch power market becomes more allocative efficient, the deficit prices on the balancing market are expected to increase over time as the more expensive power plants are allocated to deliver power via the balancing market, in case of unexpected demand (in figure: D_p).

In order to test this hypothesis we analyse the dynamics of the deficit prices over time. For instance, the average deficit price equals euro 62.68 on a 15 minutes basis in 2002 and euro 100.50 per 15 minutes in 2003; a clear increase in price has become apparent. To test more formally, we estimate the parameters in the following equation.

1) $$P(t) = \alpha + \beta\, P(t-1) + \gamma\, t + \varepsilon(t), \quad \varepsilon(t) \sim IID\,(0, 1)$$

That is, we model the dynamics of the deficit price level P(t) as an AR(1) process with a trend variable t that equals 1 for the first 15 minutes in our sample, 2 for the second 15 minutes and so forth. From an augmented Dickey-Fuller test on the price levels, we rejected a unit root. We use price levels instead of

[8] Pre-liberalisation policy: 1/3 gas, 1/3 coal and 1/3 nuclear power, EnergieNed (2003).

natural logarithms as unbalancing prices can become negative. We included the trend term to test directly for a price increase over time, by interpreting the estimate for γ. Table 2 contains the estimation output from above equation.

From table 2, we observe the positive and significant estimate for the parameter γ that is the coefficient for the trend variable in equation 1. The estimated value of 0.0001 is low, but reflects the average price increase over 15 minutes intervals over a two-year time period. This confirms our hypothesis that the deficit prices in the unbalance markets have increased over time due to improving allocative efficiency.

Table 2 This table presents the estimates and t-values in parentheses of the parameters in equation 1 using ordinary least squares.

Parameter	Estimate
α	5.0298 (7.4031)
β	0.8670 (319.4501)
γ	0.0001 (7.5836)
R^2	0.7762

We now focus on the balancing volumes, which are indicators for security of supply as discussed in section 2. The existence of the day ahead APX and real-time balancing market makes that the incentives are created for accurate supply-demand matching for expected demand and unexpected demand. If the markets become more allocative efficient, energy firms have improved capabilities to make demand expectations, which should lead to lower unbalance volumes.

Both Scheepers and Van Werven (2004) and EnergieNed (2003) argue the relation between unbalance volumes and security of supply. Lower unbalance volumes result in fewer shocks to the system such that security of supply improves as long as a minimum level of reserve capacity is guaranteed. If the Dutch market becomes more allocative efficient, we expect balancing volumes to decline.

Comparing 2002 and 2003, we observe that the average volume numbers declined. For instance, the average net unbalance volume decreased from 16.41 MW on a 15 minutes basis in 2002 to 9.85 MW per 15 minutes in 2003, an allocative efficiency improvement of almost 40%. The average absolute unbalance volume (the sum of surplus and deficit volume) decreased from 121.89 in 2002 to 97.69 in 2003, being an almost 20% improvement.

To test this more formally, we estimate the parameters in a similar model as in equation 1. Let V(t) be the unbalance volume, respectively surplus, deficit, absolute and net balance volume.

2) $V(t) = \alpha + \beta V(t-1) + \gamma t + \varepsilon(t), \quad \varepsilon(t) \sim IID(0, 1)$

The parameter estimates are presented in Table 3.

Table 3 This table presents the estimates and t-values in parentheses of the parameters in equation 2 using ordinary least squares.

Parameter	Surplus	Deficit	Absolute	Net
α	6.1717	10.1707	8.2972	5.3847
	(39.4038)	(50.4623)	(35.1154)	(25.5889)
β	0.8929	0.8734	0.9399	0.7633
	(524.8990)	(474.8484)	(728.4109)	(312.7338)
γ	-0.00003	-0.00007	-0.00004	-0.00006
	(-9.3003)	(-19.3574)	(-12.1655)	(-12.8389)
R^2	0.8017	0.7817	0.8913	0.5899

Table 3 shows the negative and significant coefficient for the trend variable. Although the levels are low, reflecting the average decline over a 15 minutes interval, it is observed that all unbalance volumes decrease over time. This confirms our prior expectation that unbalance volumes should decline due to increase allocative efficiency. This is also an indication for increased security of supply in the Dutch power market.

5 Concluding remarks

This paper provides evidence for increased allocative efficiency in the Dutch power market. By examining the prices and volumes in the Dutch unbalance markets over the years in 2002 and 2003, we found that unbalance prices increased and that unbalance volumes declined. The price increase can be explained by allocative efficiency as cheaper production facilities are better allocated in the merit order of the day ahead market and that only more expensive production facilities are available for unbalance volume. The volume decrease can be explained by improved demand forecasts of energy firms, which leads to fewer shocks to the system. This has a positive effect on the security of supply as long as a minimum reserve level is maintained. Although we only provide partial evidence on increased allocative efficiency, we conclude that the energy resources are better allocated in terms of production costs and that energy firms have improved their forecasts on consumer demand.

6 References

Boles De Boer, D. and Evans, L., 1996, “The Economic Efficiency of Telecommunications in a Deregulated Market: The Case of New Zealand”, *The Economic Record*, 72 (216), pp. 24-35.

Button, K. And Weyman-Jones, T., 1992, “Ownership Structure, Institutional Organization and Measured X-efficiency”, *American Economic Review*, Vol 82 (2), pp 439-445.

EnergieNed, 2003, *“Condities voor een betrouwbare energievoorziening”,* May 16th 2003, pp 1-33, EnergieNed Arnhem.

European Parliament and Council, 1997, “96/92/EC Directive of the European Parliament and Council”, *Official Journal*, 27, pp 20-29, Brussels.

European Parliament and Council, 2003, “2003/54/EC Directive of the European Parliament and Council”, *Official Journal*, L176, pp 37-56, Brussels.

Farrel, M., 1957, “The Measurement of Productive Efficiency”, *Journal of the Royal Statistics Society*, Series A 120 (3), pp. 253-282.

Frantz, R., 1988, “*X-Efficiency: Theory, Evidence and Applications”*, Kluwer Academic Publishers.

Green, R. and Newbery, D., 1992, “Competition in the British Electricity Spot Market.”, *Journal of Political Economy*, 100 (5), pp. 929-953.

Harberger, A., 1954, “Monopoly and Resource Allocation”, *American Economic Review*, 44 (2), pp. 77-87.

Leibenstein, H., 1966, “Allocative Efficiency vs X-Efficiency”, *American Economic Review*, 56 (3), pp. 392-415.

Megginson, W. and Metter, J., 2001, “From State to Market: A Survey of Empirical Studies on Privatisation”, *Journal of Economic Literature*, 39, pp 321-389.

Ministry of Economic Affairs, 2002, *“Energy Report*”, pp. 1-72, The Hague.

Newbery, D. Von der Fehr, N. and Van Damme, E., 2003, “Liquidity in the Dutch Wholesale Market”, *DTe Working Paper*, pp. 1-26.

Van Werven, M. and Scheepers, M., 2004, “Monitoren van Voorzieningszekerheid”, *ECN Working Paper*, pp1-44.

Pollitt, M., 1995, *“Ownership and Performance in Electric Utilities”*, Oxford Press.

Wenting, F., 2002, *“Programmaverantwoordelijkheid”*, August 20th 2002 ,pp.1-13, Tennet Amsterdam.

Wolfram, C., 1999, “Measuring Duopoly in the British Electricity Spot Market”, *American Economic Review*, 89 (4), pp. 805-826.

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