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Economic impact of regulatory reforms in the electricity supply industry: a panel data analysis for OECD countries

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Abstract

This paper reexamines the impact of the regulatory reforms on price in the electricity supply industry, using panel data for 19 OECD countries for the period 1987–1999 and compares the results with those found in an earlier study by Steiner (Regulation, industry structure and performance in the electricity supply industry, OECD Economics Department Working Paper, ECO/WKP, 2000, p. 11). We found that expanded retail access is likely to lower the industrial price and increase the price differential between industrial customers and household customers, as expected. We also found that the unbundling of generation and the introduction of a wholesale spot market did not necessarily lower the price and may possibly have resulted in a higher price. This finding is not consistent with expectations and differs from Steiner (2000), but it is plausible in the light of recent experiences in many countries.

Keywords: Regulatory reforms; Electricity prices; OECD countries

1. Introduction

Regulatory reforms in the electricity supply industry have been observed in many parts of the world. In most countries, the industry had traditionally been characterized as a regulated monopoly, and reform has opened it to competition at the wholesale level as well as the retail level. The industry was also typically characterized as a vertically integrated structure, while reform has unbundled generation and supply from transmission and distribution. The UK and Norway were among the first countries to introduce competition into the wholesale and retail markets as well as unbundling services early in the 1990s. The UK also privatized the national electricity industry. Many countries have followed these regulatory reforms to achieve more efficiency in their electricity supply industries. There is now a need for a detailed evaluation on the economic impact of the reforms, because such reforms appear to be costly and there seems to be a growing controversy as to their benefits. An increasing number of empirical studies have measured the impact of regulatory reforms in various ways.[1] Most of the empirical studies thus far have focused on a single country; however, Steiner (2000) has made a unique contribution in conducting cross-country analysis of the impact of regulatory reforms in the electricity supply industry.

Steiner analyzed the effect of regulatory reforms on the retail price for large industrial customers as well as the ratio of industrial price to residential price, using panel data for 19 OECD countries for the period 1986–1996. Steiner found that regulatory reforms to introduce competition into the industry, including the creation of a wholesale spot market and the unbundling of electricity generation from transmission, generally induced a decline in the industrial price and an increase in the price differential between industrial customers and residential customers, indicating that industrial customers benefit more from the reform. These results support some policy recommendations currently made by the OECD. For example, in its policy recommendation of structural separation in the network industries, OECD (2001) judges that the results show signs of enhanced competition in the electricity supply industry from the unbundling of generation. Although the analysis was carefully conducted as a first step in assessing the impact of the reforms, it has several shortcomings and needs to be improved before reaching a consensus as to the policy recommendation. Moreover, the rapid development of the reforms in many

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[1] See Pollitt (1997) for a survey of such studies.

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countries after 1996 would alter some of the estimates, even if we use the same model.

This paper reexamines the impact of the regulatory reforms on price in the electricity supply industry in OECD countries and compares our results with those found in the earlier study by Steiner. We carefully reviewed the recent development of the regulatory reforms in OECD countries to define several indicators of the reform, including the extent of retail access, unbundling of generation from transmission, and the introduction of wholesale spot (pool) markets. We then estimated the influence of each of these on the level of industrial price and the ratio of industrial price to residential price, using panel data for 19 OECD countries for the period 1987–1999. The next section explains the regression model, estimation technique, and data set we used for the analysis, with special attention given to explaining data for regulatory indicators. The third section presents the results and discusses the implications. The final section concludes our analysis.

2. The model, estimation, and data issues

Following Steiner, we formulate regression equations to analyze the impact of regulatory reform in the electricity supply industry on the level of the industrial price and the ratio of the industrial price to the residential price. The two equations are estimated separately. Denoting the price level or price ratio as y, the equation is written as follows:

$$y_{it} = \alpha + X'\beta + Z'\gamma + \mu_i + v_{it},$$

where X is a set of regulatory reform indicators to reflect the degree of reform in various components of regulatory policy and Z is a set of independent variables not directly related to regulatory reforms.[2] Subscript i indicates the country and t indicates the time period. μ_i accounts for an unobservable time-invariant country-specific effect, while v_{it} is the normal disturbance term.

We assume that the country-specific effect exists, and we utilize some basic panel-data-estimation techniques, namely, a one-way fixed effect model and a one-way random effect model. In the fixed effect model, the country-specific effects are assumed to be the fixed parameters to be estimated. In the random effect model, the country-specific effects are treated as stochastic. The fixed effect model produces consistent estimates, while the estimates obtained from the random effect model will be more efficient. A Hausman test is used to determine which model is preferred. Note that the coefficients β and γ are identical across countries.

In this study, we have not attempted to change the estimation strategy to overcome several caveats expressed in Steiner's study. We have chosen instead to focus on the changes in results by extending the sample period and by modifying the definition of regulatory indicators, as explained below. Thus, our study faces the same potential problem as Steiner's study. The above single equation model does not consider endogeneity of the right-hand variable, for example. If, in fact, the decision as to the regulatory reforms is influenced by past electricity prices or price ratios, then we are faced with the problem of simultaneity bias. This is, of course, an area of future research, but we have ignored these kinds of possibilities.

Our data set is based on a panel of 19 OECD countries for a period beginning in 1987 and extending through 1999.[3] The countries of our sample are the same as those of Steiner.[4] Because of the missing observation, our panel is unbalanced and the total number of observations is 232.

The dependent variable for the price level equation is the industrial price before taxes converted into US currency by purchasing power parity and deflated by the consumer price index. The dependent variable for the price ratio equation is the ratio of industrial price to household price (industrial price/household price). Clearly, the ratio will decrease if the industrial price falls faster than the household price. Since industrial prices are generally lower than household prices, the declining ratio means a larger price differential between the two groups of customers. These price data are taken from *Energy Prices & Taxes* published by the International Energy Agency. As there are some missing observations in price data during our sample period, our panel data are unbalanced. For Norway, the industrial price data after 1993 are not available from *Energy Prices & Taxes*, and thus we rely on data published from Statistics Norway.[5] For Canada, as data for price before taxes are not available for the entire sample period, we use the after-tax (provincial tax) price as an exception. We ensure that our results are robust by estimating the equation with and without these samples.

Steiner included the shares of hydro generation, nuclear generation, and gross domestic product (GDP) as independent variables not directly related to

[2] See also Yajima et al. (1999) for an econometric study of reforms where regulatory and institutional characteristics enter as variables.

[3] Steiner's study covers the period 1986–1996. Our data set covers the period from 1987 simply because the data is electronically available.

[4] The 19 countries are: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States.

[5] The industrial price in Norway excludes the energy-intensive industry because the customers in this industry had received large discounted electricity rates before liberalization. The effect of liberalization on prices for these customers would be different from what is generally expected.

regulatory reforms (Z). For the share of different generation technology, we used the share of hydro capacity and nuclear capacity instead of their generation (MWh) shares, as the price would reflect the need for recovering the capital expenditure as well. We expect that a higher share of nuclear capacity will lead to higher prices, while a higher share of hydropower capacity will lead to lower prices. Capacity data are taken from the *International Energy Annual* published by the Energy Information Administration. GDP is converted into US dollars in 1995 using purchasing power parities, and the data are taken from *Energy Balances of OECD Countries* by the International Energy Agency.

Our choice of the regulatory reform indicators (X) is basically the same as that of Steiner; it includes unbundling of generation from transmission, third party access, wholesale spot market, private ownership, time to liberalization, and time to privatization. However, we independently collected the data for these indicators, and we define each of these indicators to reflect recent development of regulatory reforms, as it is critical in this kind of empirical study to carefully define such indicators.[6] While some of these regulatory reform variables are defined in a similar way to those in Steiner, they are not necessarily the same. In fact, some of the definitions of these variables are slightly modified. Since the assessment of individual components of regulatory reforms is the main focus of this paper, we explain the definition of each of these indicators and the difference between our definitions and those of Steiner. We note at this time that we have assumed that the decisions to implement each of these policies in different countries are essentially the same across the countries.

2.1. Unbundling (generation from transmission)

In order to measure the effect of unbundling of generation from transmission, we created a dummy variable to indicate the degree of the unbundling. We assume that the effect of unbundling will be realized if the transmission system operator (TSO) becomes a separate entity. In other words, we do not regard accounting separation within the same entity as unbundling. Steiner defined the dummy variable so that it takes a value of one if there is either an accounting separation or a legal separation and zero otherwise. Our dummy variable for the unbundling takes a value of one if there is a legal separation of system operation and generation. In countries where different states or provinces have different policies as to unbundling, the variable takes a value of one if at least one state or province ordered a legal separation of system operation. In general, unbundling of generation from transmission is regarded as a necessary condition to promote competition in the generation sector (by facilitating new entrants), thereby lowering the price. However, it is also pointed out that there are economies of vertical integration in the electricity supply.[7] Thus, this variable would take on a negative coefficient if the benefit of promoting competition outweighed the loss of vertical integration. Since 1997, several countries in Europe, including Denmark, the Netherlands, and Italy, have established some kind of TSO as a separate entity, and in the US, several states and regions have established independent system operators (ISOs). In our sample, as of 2000, five countries (France, Germany, Greece, Ireland, and Japan) had not required a legal separation of generation and transmission.

2.2. Retail access (or third party access)

In order to measure the effect of giving customers access to alternative suppliers, we created discrete variables to reflect the degree of retail access. Specifically, the variable takes a value of one if the country has passed legislation requiring a part of the customer group to have a choice among suppliers in the retail electricity market, and two if the country requires all customer groups to have this choice.[8] In countries where different states or provinces have different policies as to retail access, the variable takes a value of one if at least one state or province gives some customers access to the retail market, while it takes a value of two only if all states or provinces give all customers retail access. We regard this variable as corresponding to the third party access (TPA) indicator in Steiner's study, since TPA is usually established at the same time as the retail access program is started. Steiner defined a dummy variable so that it takes a value of one if there is either negotiated or regulated TPA and zero otherwise. Giving more customers a choice in the retail market will enhance competition among producers as well as suppliers, leading to lower prices as a whole. Moreover, it could lead to a lower industrial price relative to household price. This is highly expected, as more suppliers are willing to serve industrial customers than residential customers. There is also the possibility that restructuring

[6] These indicators are constructed by using a number of publicly available sources, including the European Commission (2000, 2001), EU–Japan Center (2000), and Commission of the European Community (2001).

[7] See, for example, Kwoka (1996) for empirical evidence of economies of vertical integration in the electricity supply industry in the US.

[8] In some countries, the degree of retail access is expressed as the share of the retail market that is subject to competition, but in many other countries it is represented by customer classes that are eligible for retail access. We chose a discrete variable because we were not able to obtain for all the countries the market shares by customer class that are necessary for the computation of the total share of the retail market open to competition.

has tended to diminish the cross-subsidization that previously prevailed and penalized large customers. Following an EU Directive in 1997, EU member countries had to open their retail markets at least partially by 2000, though many of the countries opened their markets well in advance. In fact, by 2000, all EU member countries except Greece had opened their retail market. In the US, several states have introduced retail choice since 1997, and half the states have decided to implement retail choice since 2000.

2.3. The wholesale spot market

This variable indicates the existence of a wholesale power pool market where hourly or half-hourly spot prices are determined.[9] We believe that we use the same definition as Steiner; the variable takes a value of one if there is a wholesale electricity market and zero if there is not. In countries where different states or provinces have different policies as to the wholesale spot market, the variable takes a value of one if at least one state or province establishes such a market. A wholesale power market is established in order to facilitate competition among generators and encourage new entrants into the market. Therefore, it is generally expected that the wholesale power market will lead to lower retail prices through the lower wholesale prices induced by competition. However, it is becoming more readily accepted in policy circles that the wholesale electricity market is considered to be particularly vulnerable to the market power of large generators, which is causing higher prices.[10] Thus, we can only expect this variable to take on a negative coefficient if the wholesale market is workably competitive. There has been rapid development of wholesale electricity markets in OECD countries since 1997. In Spain and the Netherlands, new power markets have been opened, and in the US, several regional power markets started operation from 1998. Finland and Denmark have joined Nordpool, a Nordic power exchange. Other countries, including France, Germany, and Italy, have opened or planned to open a power exchange after 2000.

2.4. Private ownership

This variable measures the effect of the different degrees of private ownership of the electricity supply industry. Steiner's indicator for ownership has five different levels (0 = public, 1 = mostly public, 2 = mixed, 3 = mostly private, and 4 = private), but the criteria to distinguish the levels are not clear. Our indicator has four different levels based on the following criteria: if the share of private ownership in electricity generation in a country is less than 25%, it takes a value of zero; if the share of private ownership is less than 50%, it takes a value of one; if the share is less than 75%, it takes a value of two; and three otherwise. It has long been debated whether private ownership is more efficient than public ownership.[11] Although it is often argued that a privately owned firm is more efficient in production than a publicly owned firm, it does not necessarily lead to a lower price because of the profit-maximizing behavior of the privately owned firms. Public ownership of the national electricity industry was the dominant form of market governance for the industries in the UK, Australia, and New Zealand prior to their liberalization decisions but these industries were privatized subsequently. Conversely, private ownership of regional electricity industries was and continues to be dominant in the US and Japan, whereas the industry in Norway remains public even after the liberalization decision.

2.5. Time to liberalization

This variable indicates the remaining years to liberalization. By "liberalization," both this study and Steiner refer to the liberalization of the generation sector or the wholesale market, not to the liberalization of the retail market. For observations following the year of liberalization, this indicator takes a value of zero. We expect this variable to take on a positive value, which indicates that the prices will be lower as the start of liberalization approaches.[12] By reacting and preparing well for the expected arrival of a competitive environment, incumbent utilities are likely to offer lower prices for their customers before competition begins.

2.6. Time to privatization

This variable indicates the remaining years before privatization. For observations following the year of privatization, this indicator takes a value of zero. In Steiner's study, the year of privatization is based on the earliest sale or public offering. We assume that privatization takes place when the share of private ownership in the generation industry is increased by more than 25%.

The appendix summarizes the development of regulatory reforms in 19 OECD countries.

[9] The so-called "tight power pool" existed in many countries before the regulatory reforms, but these are not counted in our wholesale power market.

[10] See, for example, Borenstein and Bushnell (2000) and Newbery (1995).

[11] For interesting issues involving ownership differences in the electricity industry, such as relative performance between privately owned electric utilities and publicly owned electric utilities, see Pollitt (1995) and Kwoka (1996).

[12] Note that the value of this indicator decreases as the time approaches to liberalization.

As noted earlier, the coefficient β on these regulatory indicators is identical across countries, and captures the mean effect of each indicator. We note here that the timing of the implementation of one policy does not matter with respect to the magnitude of its impact. The coefficient will capture any systematic difference by changing the value of the regulatory indicator. It may be reasonable to expect that the price would fall as competition intensifies in later periods. Such time-dependent effects will not be captured. Although we included time-dependent effects prior to liberalization and privatization, we did not take into account such effect afterwards. Given the short period of time after regulatory reforms in most countries, it may be negligible, but care must be taken when interpreting these results.

We have also assumed that the regulatory indicators are independent of each other. This may be problematic as some are influenced by other indicators, causing multicollinearity. For example, establishing a wholesale power market generally requires unbundling to facilitate open competition. For the purpose of comparison, we will maintain the assumption of independence among explanatory variables, but we will exclude some variables if we suspect the problem of multicollinearity.

3. Results

3.1. The effects on the industrial price level

We will first discuss the results of the regression analysis of the industrial price level. The parameter estimates for the regression equation are shown in Table 1. "The model 0" is the result from Steiner's study, in which few regulatory indicators are statistically significant. The existence of a wholesale power market statistically significantly lowers the industrial price. Unbundling and TPA have negative parameter estimates, but are not statistically significant. Time to liberalization and privatization are both positive, but the time to privatization is not statistically significant.[13] As expected, the share of hydro generation has a statistically significantly negative coefficient. The share of nuclear generation and GDP are not statistically significant.

In the next two columns (Models 1 and 2), we show the results obtained from our models that most closely replicate Steiner's model. These models are estimated using a data set extended to 1999. Model 1 is estimated using the fixed effect model and Model 2 is estimated using the random effect model. Although the Hausman test indicates that the fixed effect model should be chosen, we present the results of both for comparison, since Steiner's result is based on the random effect model. Comparing the results of Models 1 and 2 with those of Steiner's study, we can observe several differences. First, the existence of a wholesale power market was statistically significantly negative in Steiner's study, but is significantly positive in our models. TPA in Steiner's model was statistically insignificantly negative, but our retail access parameter is statistically significantly negative in both Models 1 and 2. The share of private ownership was statistically significantly positive in Steiner's model, but is statistically significantly negative in our models. The share of hydro capacity is negative but not statistically significant. The share of nuclear capacity is not statistically significant, either. GDP is statistically significantly negative in our models.[14]

To determine if the difference between Steiner's results and our study is caused by the different sample period, we estimate the same model using the data for the period up to 1996. The result, shown in Table 1 as Model 3, is based on the random effect model, since the Hausman test statistics indicate that the random effect model is preferred. The unbundling of generation is statistically insignificant, as in Steiner's result. The retail access also is statistically insignificant, as was the TPA indicator in Steiner's study. On the other hand, the wholesale power market still takes a statistically significantly positive coefficient, and private ownership still takes a negative coefficient though it is insignificant. Based on this comparison, the effects of unbundling and retail access shown in Models 1 and 2 are at least partly due to the extension of our data set to 1999.

One of the potential problems with Steiner's model is that it includes both "time to liberalization" and "time to privatization." These variables are highly correlated, and in fact, one of them ("time to privatization") was statistically insignificant in his model as well as our Models 1–3. We thus estimated the same model without "time to privatization," and found that the results (as shown under Model 4) are similar to those obtained in Model 2.[15] The coefficient for "time to liberalization" appears to have changed from 0.001 to 0.002, but it actually changed from 0.00139 to 0.00169. Another potential problem is that the effect of "time to liberalization" may serve as the effect of a simple linear time

[13] Steiner held that "as liberalization and privatization dates approach, prices increase." But if these variables are created literally as time remaining before liberalization or privatization, the value of these variables declines over time, and thus a positive coefficient means that as liberalization and privatization dates approach, price decreases.

[14] The interpretation of the negative coefficient for GDP is somewhat difficult but it might have captured the income effect on demand, as most price data are defined simply as revenue divided by sales in kWh.

[15] Multicollinearity is also suspected between unbundling and the wholesale power market, but excluding one of these does not affect the estimates of the other variables.

Table 1
Regression results for the analysis of the price level

Model	0	1	2	3	4	5
Sample period	1986–1996	1987–1999	1987–1999	1987–1996	1987–1999	1987–1999
Estimation	Random effect (Steiner, 2000)	Fixed effect	Random effect	Random effect	Fixed effect	Fixed effect
Constant	0.067		0.077	0.078		
	(7.104)		(8.115)	(7.716)		
Unbundling	−0.001	0.004	0.003	−0.002	0.004	0.005
	(−0.659)	(1.940)	(1.509)	(−0.999)	(1.737)	(2.316)
Private ownership	0.003	−0.009	−0.007	−0.002	−0.009	−0.007
	(2.700)	(−6.583)	(−5.939)	(−1.118)	(−6.621)	(−5.544)
Retail access/TPA	−0.003	−0.005	−0.005	−0.002	−0.005	−0.004
	(−1.357)	(−3.251)	(−3.286)	(−1.031)	(−3.250)	(−2.339)
Wholesale market	−0.005	0.009	0.007	0.005	0.008	0.009
	(−2.306)	(3.188)	(2.619)	(1.643)	(3.063)	(3.483)
Time to liberalization	0.001	0.001	0.002	0.002	0.002	
	(2.814)	(3.773)	(5.233)	(4.871)	(9.145)	
Time to privatization	0.001	0.000	0.000	−0.001		
	(1.510)	(0.935)	(−0.120)	(−1.302)		
Share of hydro capacity/generation	−0.034	−0.027	−0.033	−0.029	−0.028	−0.031
	(−3.252)	(−0.484)	(−1.511)	(−1.276)	(−0.515)	(−0.572)
Share of nuclear capacity/generation	0.002	0.037	−0.004	−0.040	0.043	0.062
	(0.132)	(0.777)	(−0.122)	(−1.318)	(0.911)	(1.330)
GDP	0.000	−0.011	−0.006	−0.004	−0.010	−0.005
	(1.011)	(−4.217)	(−2.784)	(−1.468)	(−4.204)	(−2.184)
Time trend						−0.002
						(−9.941)
Hausman test statistics	16.39		25.59	13.19	20.21[a]	13.48[a]
(*P*-value)			0.0024	0.1544	0.0096	0.0963

t-Values in parentheses.
[a] Hausman test statistics based on the corresponding random effect model.

trend, by which the effect of technological progress in the electricity supply industry throughout the world may be captured. To see if the effect of "time to liberalization" differs from the effect of the time trend, we replace the "time to liberalization" with the linear time trend and estimate the model again. Since the time trend is increasing over time while "time to liberalization" is defined to be decreasing over time, the estimate on the time trend takes the opposite sign but its magnitude (0.00180) is about the same as the estimate of the "time to liberalization" in Model 5 (0.00169). We also observe that changing this variable does not very much affect the estimates of the other variables.[16]

The above results are robust if we exclude observations from Norway and Canada, for which we took price data from a different source or used prices including tax, or if we exclude the shares of hydro and nuclear capacities. They are also robust if we use a simple dummy variable to indicate the introduction of retail access (taking a value of one if retail access is introduced at least for a part of the customer base and zero otherwise), instead of our two-step indicator of retail access.

3.2. The effects on price structure

Now let us turn to the results of the price ratio equations. Again, in Table 2, the results of Steiner's model are shown in the column under Model 0, and our models replicating Steiner's model with the extended data set are shown in the column under Model 1 (the fixed effect model) and Model 2 (the random effect model). According to the Hausman test statistics, the random effect model is rejected in favor of the fixed effect model at the 5% level but not at the 1% level. Thus, we showed both results, though they are not greatly different.

Comparing the results of Models 1 and 2 with that of Steiner, we again point out several noticeable differences. Although unbundling and retail access/TPA have the same sign, the magnitude and statistical significance for each parameter is somewhat different. In our models, the coefficient for unbundling is smaller in magnitude relative to Steiner's estimate and is not statistically significant at the 1% level, while the

[16] One exception is the parameter estimate on unbundling. It turns out to be statistically significant (and remains positive).

Table 2
Regression results for the analysis of the price ratio

Model	0	1	2	3	4
Sample period	1986–1996	1987–1999	1987–1999	1987–1996	1987–1996
Estimation	Random effect (Steiner, 2000)	Fixed effect	Random effect	Fixed effect	Random effect
Constant	0.528		0.647		0.646
	(9.684)		(32.625)		(31.330)
Unbundling	−0.051	−0.022	−0.026	−0.043	−0.046
	(−2.425)	(−1.635)	(−1.921)	(−2.741)	(−3.020)
Private ownership	0.035	−0.001	−0.006	0.008	0.001
	2.786	(−0.167)	(−0.799)	(0.829)	(0.166)
Retail access/TPA	−0.035	−0.071	−0.068	−0.063	−0.060
	(−1.755)	(−7.399)	(−7.092)	(−4.652)	(−4.523)
Wholesale market	−0.114	0.027	0.030	0.040	0.046
	(−3.861)	(1.688)	(1.879)	(1.824)	(2.145)
Hausman test statistics	18.22		11.77		11.55
(*P*-value)			0.0192		0.0211

t-Values in parentheses.

coefficient on retail access is larger in magnitude relative to Steiner's estimate for the TPA indicator and is statistically significant. The share of private ownership and the wholesale power market in our models have different signs from those of Steiner's estimate. In our model, the estimates of these variables are statistically insignificant.

To see if the difference between Steiner's results and those of our study is caused by the different sample period, we estimate the same model using the data for the period up to 1996. The results are shown in the columns under Models 3 and 4. Again, the random effect model is rejected at the 5% level of significance but not at the 1% level, and thus we present both results. In terms of unbundling, the magnitude of the estimate becomes larger as compared to Models 1 and 2 and gets closer to the estimate of Steiner. In terms of retail access, the magnitude of the coefficient becomes somewhat smaller as compared to Models 1 and 2 but it is still statistically significantly negative. The share of private ownership is still statistically insignificant but is positive, as is Steiner's result. The wholesale power market still has a positive sign, and in the random effect model (Model 4), the estimate is statistically significantly positive.

Some differences between Steiner's results and ours remain even after adjusting the sample period, indicating that there are some differences in data sets. Giving more customers access to the retail market tends to increase the price differential between the customer groups in favor of industrial customers. The unbundling of generation from transmission seems to have increased the differential between the customer groups, as was indicated by Steiner and our Models 3 and 4. We found, however, that this impact (the magnitude of the parameter and its statistical significance) became somewhat weaker as we extended the data set to 1999.

3.3. Discussion

Let us summarize our findings from the two equations in relation to the impact of regulatory reforms. First, we found that expanded retail access is likely to lower the industrial price, while at the same time increasing the price differential between industrial customers and household customers, as expected. This was an expected consequence of the liberalization of the retail market, and possibly enhances efficiency by rebalancing the price structure. This result is largely due to the actual expansion of retail access after 1996—when we estimated the same model using the data for the period through to 1996, the parameter estimate on the indicator of retail access was statistically insignificant in the price level equation as well as the price ratio equation, as was found in Steiner's estimate on TPA. Steiner interpreted this to mean that the legal TPA might have not resulted in actual entry, but it seems that the incumbents in the industry have reacted to the competitive environment in the retail market to prevent large customers from switching to another supplier.

Second, we found that the unbundling of generation did not necessarily lower the price and may have possibly resulted in a higher price. Both Steiner's study and our estimation (with one exception) showed that the effect of unbundling on the level of industrial price is statistically insignificant. In addition, though insignificant, our estimates based on the data up to 1999 all show positive coefficients (and one of them is statistically significant). Like Steiner, our estimation using the data for the period through 1996 found that the unbundling led to lower industrial prices relative to household prices. However, this effect becomes somewhat ambiguous when we estimate the model using the data to the end of 1999. Although the OECD recommends a stricter form of unbundling, our results

show that there is no statistically significant evidence that it leads to a lower industrial price or a lower industrial price to household price ratio. These results indicated that "a sign of enhanced competition" is no longer observed.[17] It is possible that unbundling of generation from transmission increases the transaction costs that would be paid by final customers. Economies of vertical integration might be lost as a result of a strict form of unbundling, making the net impact of unbundling ambiguous. Of course, the insignificance of the parameter might indicate that the degree of success of unbundling differs between countries; unbundling has led to lower prices in some countries but not in others.

Third, we found that the introduction of a wholesale power market did not necessarily lower the price, and may indeed have resulted in a higher price. Our estimates using data up to 1999 show, without exception, that establishing a wholesale power market resulted in statistically significantly higher prices and also increased the ratio of industrial price to household price, although not in a statistically significant manner. Our findings as to the spot market are not consistent with expectation and differ from those of Steiner, even if we adjust the sample period. Thus, we cannot draw a strong conclusion as to the impact of a wholesale power market. Our result indicates that the introduction of a wholesale power pool has increased industrial prices and might decrease the price differential between industrial price and household price (i.e., industrial price relative to household price becomes higher). Since large industrial customers often directly purchase power in such a market, the increase in their price and the price ratio are not surprising. It has been observed that electricity spot markets are vulnerable to generators' exercising market power, and a number of studies provide ex-ante analysis of the possibility that market power is likely to be exercised.[18] Some recent studies have provided empirical evidence that market power is actually exercised in the wholesale power market in UK and the US.[19] Our result may be plausible in the light of the experiences in these countries, but it would be prudent to wait for future research to determine whether the existence of market power actually led to a higher price.

Forth, we found that a large share of private ownership lowers the industrial price but may not alter the price ratio between industrial and household customers. Our estimates using data up to 1999 show that a higher share of private ownership resulted in statistically significantly lower prices (with one exception) and did not affect the ratio of industrial price to household price in a statistically significant manner. Our findings on private ownership differ from those of Steiner. Although it may partly be due to the different sample period, we cannot draw a strong conclusion as to the effect of private ownership. We believe that our data set and that of Steiner are not significantly different, but the results call for further examination.

An important challenge in this kind of empirical study is how to specify the policy variables associated with regulatory reforms as well as how to define appropriate performance measures. The comparison made in this study sheds some light on the importance of carefully inspecting the structural and institutional dimensions of the reforms during the analysis of their economic impact. The results may be sensitive to such specifications, and therefore, one must be very careful in deriving a policy recommendation based on this kind of empirical analysis. New development in regulatory reform would necessitate creating new indicators and modifying some existing indicators.

4. Concluding remarks

This paper reexamined the economic impact of the regulatory reforms in the electricity supply industry using panel data for OECD countries. We found that expanded retail access is likely to lower the industrial price, and at the same time increase the price differential between industrial customers and household customers, as expected. This result is largely due to the actual expansion of retail access after 1996—when we estimated the same model using data for the period to the end of 1996, the parameter estimate of the indicator of retail access was statistically insignificant. We also found that the unbundling of generation and the introduction of a wholesale spot market did not necessarily lower the price, and may possibly have resulted in a higher price. The findings as to the unbundling and the spot market are not consistent with expectation and are different from those of Steiner. However, our results are plausible in the light of the experiences in some countries. It is possible that the unbundling of generation from transmission increases transaction costs, which would be paid by final customers. It has also been observed

[17] We would like to note here that even if a lower industrial price relative to household price is realized, without evidence of a lower price level, it is questionable whether this can be regarded as a sign of enhanced competition, as the OECD (2001) claims.

[18] The study by Green and Newbery (1992) simulates the potential for market power in the UK power pool. Other such studies include Brennan and Melanie (1998) for the Australian market, Ocana and Romero (1998) for the Spanish market, and Borenstein and Bushnell (1999) for the Californian market. These studies all basically find that there is a significant potential for market power without any countermeasures.

[19] Wolfram (1999) measured the actual level of market power of the two large generators in the UK power pool. Borenstein et al. (2002) showed that market prices in California since 1998 were higher than their estimated marginal cost particularly during the summer and concluded there was an increase in the market power of generators.

Table 3
Regulatory reforms in the electricity supply industry in OECD countries

	Unbundling	Retail access		Wholesale spot market
		Partial	Full	
–1989	BEL, ESP			
1990	GBR	GBR		GBR
1991		NOR	NOR	NOR
1992	NOR, SWE			
1993		NZL		
1994	NZL, POR	AUS	NZL	AUS
1995	AUS	FIN, POR		
1996	CAN	SWE	SWE	CAN, FIN, NZL, SWE
1997	FIN	USA	FIN	
1998	DEN, NED, USA	DEN, GER, ESP	GER, GBR	ESP, USA
1999	ITA	NED, ITA		DEN, NED
2000		*BEL, FRA, IRL, JPN*		*GER*
2001		*CAN,GRE*	*CAN*	*FRA*

Country names: AUS (Australia), BEL (Belgium), CAN (Canada), DEN (Denmark), FIN (Finland), FRA (France), GER (Germany), GRE (Greece), IRL (Ireland), ITA (Italy), JPN (Japan), NED (The Netherlands), NZL (New Zealand), NOR (Norway), POR (Portugal), ESP (Spain), SWE (Sweden), GBR (United Kingdom), USA (United States).
The entries in italics indicate information outside the sample period in this study.

that electricity spot markets are vulnerable to the exercise of market power by generators.

In conclusion, these results indicate that there is a need for further analyses of the effect of reforms in the electricity supply industry. They also indicate that it is too early to reach concrete judgments as to policy recommendation for countries considering such reform in the future. The industry may yet be in a transitional state in which the policy makers are still working hard to "get it right". It may take much more time for the welfare enhancing effect of reforms to be realized. Estimation of the long-run effects of the reform on prices will have to wait until a longer time series becomes available, although it should not be forgotten that market participants will always respond very quickly to a changing electricity environment. The regulatory reform in the electricity supply is still an on-going process in many countries, and this underscores the importance of continuing efforts to analyze the net impact of the reform, as most of the reform policies are irreversible.

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Appendix

The regulatory reforms in the Electricity Supply Industry in OECD countries are shown in Table 3.

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