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Success of political reform in electricity markets: A dynamic panel approach applied to South America

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Abstract

This article uses dynamic panel data analysis to examine the impacts of regulatory reforms in the electricity sector. We find that short term negative effects of ownership unbundling are approximately cancelled out by later positive impacts. Third party access seems to allow taking the benefits but avoiding the costs of ownership unbundling. The implementation of electricity exchanges has a positive impact on end user prices and thus appears to reveal real costs and risk of electricity production. The independency of regulatory authorities shows to have lagged price decreasing influence. Further, market coupling activities in South America, the object under study, seem to merit further expansion.

Keywords

(de)regulation, dynamic panel data analysis, electricity markets, market organization

JEL-Classification: C, L

The authors are solely responsible for the contents which do not necessarily represent the opinion of the Chair for Management Science and Energy Economics.

1. Introduction

Since the creation of the European Coal and Steel Community in 1951, one of the primary interests of the later European Union remained making sound economic policy by promoting allocative efficiency and pursuing fair distribution. Regarding economic policy in the energy sector the overall goal has been to promote competition to make efficient market outcomes possible. Central policies in this respect comprise the formation of a single market and the opening of markets, establishment of non-discriminating third party access to grids and networks, and unbundling of monopolistic bottlenecks from potentially competitive value chain levels.

There has already been achieved a consensus among most politicians and economists on a lot of reform measures. This concerns for example the implementation of third party access. On the other hand, economists still disagree on the closely related political measure of ownership unbundling of monopolistic bottlenecks, because theoretical arguments are put forward in favour of as well as against ownership unbundling. Given the theoretical trade-offs an empirical investigation seems appropriate in order to clarify whether softer measures like legal unbundling or independent transmission system operation are sufficient to make efficient operation in the potentially competitive segments possible. Further unresolved questions remain e.g. around the impact of an introduction of energy exchanges or independent regulatory authorities, and also on the effects of a privatisation of public utilities.

A lot of applied research on these topics has already been conducted. Mostly, static approaches are used to examine the effects on efficiency, prices, and distributional consequences. However, empirical evidence so far indicates that market reforms induce slow adaptation processes or even reversal of initial trends and effectiveness of reforms is thus not easily measurable. A prominent example in this context is the British restructuring and privatisation process. Only after several supplementary reforms competition in the wholesale electricity market started to work effectively.[1] These additional measures included for example the sale of capacity or a temporary imposition of price-caps at the generation level. Therefore, dynamic investigation frameworks may offer deeper insight, allowing to account for such lags. This paper examines dynamic structures and lagged impacts of the above mentioned reforms in electricity markets on residential and industrial end prices.

For an empirical analysis, the South American continent seems to be a suitable studying object. Many countries introduced regulatory reforms during the past two and a half decades, following varying and diverse routes[2]. Law giving bodies have often chosen a moderate reform speed so that effects can more easily be traced back to separate policy causes. Moreover, empirical evidence on development and transition countries is still scarce.

After a method review over the different commonly used approaches to policy evaluation and a short overview of literature on regulatory policy evaluation in the electricity sector in section 2,

[1] Cf. Newbery and Pollitt (1997).

[2] This makes it easier to identify statistically the effects of reforms compared to an analysis of EU countries. In EU countries a large proportion of the reforms has been triggered by the EU directives and occurred at similar points in time. Thus it is difficult to separate their effects from other simultaneously occurring events, e.g. macroeconomic downturn.

section 3 describes the chosen method, the data and the model specification. Section 4 discusses results of simple OLS regression. The estimation strategy is then modified in section 5 to check the robustness of results using other regression frameworks. Section 6 and section 7 then address on the one hand residential prices and on the other hand distributional effects of reforms. The latter uses residential-industrial price differences as explained variables. In the eights section the focus shifts to an international investigation object, the degree of progress in market coupling activities. The last section draws main conclusions and gives an outlook.

2. Methodological Approaches and Literature review

2.1 Failures of Culture

Several approaches have been applied to analyse the success of political reforms. Firstly, the financial performance of companies undergoing certain change can directly be measured. Secondly, productivity changes can be examined employing total factor productivity approaches (TFP). Thirdly, frontier methods (FM) are an advancement in reference to TFP measures as they permit to distinguish between technical and efficiency change. Lastly, the success of reform can be evaluated using societal cost benefit analysis. The main merits and weaknesses of these approaches are briefly evoked in the following in order to provide a framework for the assessment of own achievements.

The first methodological approach, profitability measurement, does not consider possible allocative inefficiencies but just takes financial data to judge the success of policies. TFP and FM use input output ratios to examine efficiency gains. Whereas in theory this allows to examine the allocative consequences of reform activity and the analysis of thereof resulting distributional results, TFP and FM have weaknesses in making historical data comparable. This concerns first of all the capital share of costs. Most of the empirical literature tries to circumvent this problem by choosing physical proxies for capital costs. These are in most cases weak substitutes for (standardised) monetary values and thereby a source of substantial distortion. Contrarily, societal cost benefit analysis alleviates most comparability problems coming from historical data. This method takes companies with their particular history as given and tries to find a probable counterfactual to compare it with the actual development after reform. Yet, this advantage comes at the cost of substantial assumptions to be often made with a high degree of uncertainty. These comprise hypotheses on firm behaviour including the potential degree of competitive pressure or future asset replacement strategies as well as hypotheses on governmental comportment such as taxation policy. It should be mentioned that also in empirical analysis finding an adequate “counterfactual” in the form of comparable companies is a manifold task. Even if companies are satisfyingly similar regarding accounting procedures and data, distortions are still possible. One may cite as exemplary the fact that countries often privatise, whose state owned entities already dispose of quite an efficient production.[3] This may cause further distortion leading to a misinterpretation of results.

[3] Cf. Zhang et al. (2008); In a similar way in the aftermath of the restructuring of the British CEGB, the government only sold the more modern nuclear power plants (as British Energy) and kept the elderly ones in public ownership cf. Newbery and Pollitt (1997)..

2.2 Literature

Applied research on electricity sector reform is quite extensive on some of the policy issues discussed in this article and mostly regroups under one of the above described methods. We will draw on some important work for this article as well as on more recent studies and summarise their main conclusions.

Pollitt (2008) gives a detailed and profound discussion of possible and probable advantages and drawbacks of unbundling. Among the most important drawbacks of ownership unbundling, he finds transaction costs at the introduction stage and increasing cost of capital due to an increase in risk. On the other hand the scope for discrimination against non-integrated rivals reduces. This promotes competition. Among the other factors, security of supply, synergy effects, and the facilitation of privatisation rank lower in importance. All of these effects may have positive and negative impacts. However, usually either of the impacts is more pronounced than the other.

Steiner (2000) empirically analysed the effects of unbundling[4], third party access, and privatisation on end user prices and different efficiency proxies in 19 OECD countries. In her examination of reform impacts on end user prices, she finds strong support for the hypothesis that the introduction of a wholesale market will lower prices, whereas private ownership seems to increase electricity prices. Unbundling and third party access were found to have no significant influence. This is contrasted by a second regression of a domestic/industrial customer price ratio on regulatory variables. Here, unbundling, third party access, and the spot market introduction variable were significant. Regarding influences on efficiency, Steiner (2000) uses the average capacity utilisation rate and reserve margins as proxies. In this specification only unbundling and privatization are significant. It should be mentioned that the average capacity utilisation-proxy can lead to distortion between countries. There is a natural difference between those countries which are predestined for low full load hours technologies like water and wind power and those countries with high average capacity utilisation rates because of a dependence on coal or nuclear technologies. In South America most countries have a substantial share of water power, which can rise to a (nearly) 100%-share for some countries. Under these circumstances weather will have a much greater influence than the competitiveness of the market. This makes the capacity utilisation rate as a proxy for efficiency difficult to be correctly incorporated into an empirical analysis. The same problems can arise for the reserve margin proxy.

Hattori and Tsutsui (2004) re-examine the results Steiner obtained in her study and mirror these in an analogous estimation on the basis of a similar, but longer data set. The coefficients' signs of their regulatory variables contradict the ones of Steiner (2000) in some cases. Effects of spot market introduction and privatisation are inverse to the analysis of Steiner (2000) – for the former positive and for the latter negative. Hattori and Tsutsui (2004) put forward market power as a possible explanation for price increases due to the introduction of spot markets. Further, they show unbundling to have an increasing and third party access to have a decreasing impact on end prices.

Copenhagen Economics (2005) examine diverse electricity and gas sector reforms in a study for the DG internal market. In a more sophisticated approach Copenhagen Economics (2005) first conduct a principal component analysis to find the composite variables explaining most of the variance. In the following regression analysis they obtain a negative significant influence for ownership unbundling on end user prices with regard to electricity. Nevertheless, this result is not confirmed for their gas market analysis.

Growitsch and Stronzik (2008) chose a dynamic estimation approach regarding the endogenous (price) variable, but renounce on carrying the analysis further to check for the influence of lagged exogenous (reform) variables. The focus of their analysis is the possible effects of ownership unbundling on end user prices. They see no significant influence of ownership unbundling in this static approach, but liberalisation seems to have a price decreasing impact. Third party access does not seem to have a significant influence either.

A different stream of research on the effects of unbundling uses simulation approaches. Newbery and Pollitt (1997) conduct a detailed societal cost benefit analysis of the British power producer and transmission operator CEGB. The restructuring was closely related to other reforms like privatisation and market opening. They see high efficiency gains but also higher firms' profits and losses by consumers in the restructuring process. De Nooij and Baarsma (2007) especially concentrate on a detailed analysis of costs and determine for seven out of nine cases higher costs of an introduction of ownership unbundling than benefits. The reference case is legal unbundling and the subject under study the Dutch distribution network. Brunekreeft (2008) instead focuses more on competition issues and employs a top-down analysis framework to German transmission system operators. He draws an opposite conclusion and sees a small net benefit in switching from legal or functional to ownership unbundling.

There are also single-country studies like the one of Nillesen and Pollitt (2008) on New-Zealand. Amongst others they support the conjecture of high transaction costs at the introduction stage together with decreasing unit operational costs. During the last years a lot of country case studies were published deepening the understanding and making an in-depth understanding of specific influences possible, which cannot be unveiled by statistical analysis employing typically crude proxies. Among these we find studies on prominent countries like Argentina and Chile, but also e.g. Ecuador and many others.[5] The tenor of these studies is in most cases in favour of divestiture of public firms and unbundling with a certain uncertainty of whether or not ownership unbundling has net benefits. A clear plus of these studies is that they can benefit of authors investigating alternative reasons for the failure of reforms, which sometimes are difficult to quantify and to consider in comparative econometric analyses. Yet on the other hand, those case studies and qualitative analyses obviously only provide singular insights, no statistically sound evidence. Consequently, no clear evidence has been established so far on the effects of ownership unbundling and further investigations are appropriate.

A sort of consensus has by contrast been achieved on the effects of privatisation. Megginson and Netter (2001) review the historical development, give an extensive overview of theoretical and empirical literature on the subject, discuss pro and contra privatisation arguments, characterise different sorts of privatisation, and possible sources of efficiency and welfare gains of

[4] The unbundling variable regroups all kinds of unbundling from accounting to ownership unbundling.
[5] Pollitt (2008), Pollitt (2004) and Peláez-Samamiego (2007).

privatisation. They conclude that effects of privatisation depends very much on the political, regulatory, and economic environment. For example, privatisation success would depend on specific factors like concentration rates (on generation or supply levels), public debt, etc. Zhang et al. (2008) have a similar view on privatisation effects. They use different efficiency indicators to show that the relative importance of privatisation is low relative to working competition. The analysis though is restricted to the generation level. Using frontier methods Berg et al. (2005) estimate the efficiency of privatised electricity distribution utilities in Ukraine showing that privatised utilities are significantly more efficient. Efficiency measures have also been used by Estache and Rossi (2005). They compare labour productivity of public firms under cost plus regulation to that of privately owned firms under rate of return and incentive regulation. They find rate of return regulated firms to be more efficient by trend. As expected, private incentive regulated firms are most efficient. Their analyses lead to intuitively plausible results but cannot distinguish privatisation from regulation effects and the regulatory framework seems to have a higher impact.[6] A previous study obtaining similar results has already been conducted by Kumbhakar and Hjalmarsson (1998).

A very broad analysis on privatisation, liberalisation, unbundling, investment risk and some other key factors of reforms has been conducted by Bacon and Besant-Jones (2001). They confine themselves more or less to a discussion of these factors and highlight some of the difficulties in restructuring and reforming electricity sectors in developing countries. Among these are the ambiguous effects of privatisation and its dependence on accompanying circumstances like market regulation. The authors conclude that only if investors have sufficient certainty about future returns they will invest and in turn increase competition.

Another issue, which has given rise to some debate, is the independence of regulatory bodies. Whereas Posner (1975) emphasises possible negative consequences of rent seeking behaviour, Becker (1983) argues that interest group competition favours efficient taxation. Campos (1989) shows that the choice of the political instrument is important to obtain efficient market outcome. Legislators usually maximise own expected median net present value (including influence of pressure groups) but not possible maximum social welfare. Consequently, they are prone to choose a suboptimal instrument at the first level. This can prohibit possible welfare optimal outcomes at a second stage. In a situation where the choice is between tariff regulation either by an independent agency or by a ministry, there seems to be a danger that well-organised (and endowed) pressure groups support the choice of the latter instrument. They then could uphold their influence on politicians in the ministries on second stage welfare distribution, e.g. in price regulation processes. Independent agencies contrarily should be less exposed to current policy and consequently should tend to pursue a once defined mandate more rigorously and mitigate second stage influence. Mostly these mandates pursue goals of more efficient operation and price decreases to make customers better off and to increase welfare. As a consequence, under the

[6] By using physical measures for capital costs, shifts of operating to capital expenditure are not detected, but solely improvements in labour productivity. In this case companies could replace assets, which influences their cost bases but not their physical asset base. Under rate of return regulation this pressure comes from the Averch-Johnson effect and under incentive regulation, under certain circumstances firms will have the incentive to cut short run costs (labour) in non-photo years. As their sample is quite short, this can be problematic. Also, “a measure of labour productivity gives little indication about efficiency in a capital-intensive sector like electricity.” (Zhang et al. (2008), Bacon and Besant-Jones (2001))

hypothesis that legislators are able to define an optimal mandate once, independent agencies may lead to decreasing prices. On the other hand, evidence supports the impression that also agencies are subject to substantial political influence.

Empirical literature dealing specifically with electricity regulation is scarce. Zhang et al. (2008) report relatively low importance of an independent regulatory agency on efficient behaviour of generating companies. Nevertheless, general theory suggests political influence on the second stage decision process to be more pronounced in ministries than in separate agencies. Under these circumstances decreasing prices (and thereby assumed welfare gains) from independent authorities are imaginable, but, as already mentioned, empirical analysis is still scarce.

Under comparable conditions, a systematic impact is also expected from different price regulation methods.[7] But, evidence from a lot of countries shows that both the choice of regulatory asset bases and the definition of hard external price targets is often determined by political awareness and pressure, and rather independent of the form of price regulation. This can lead to low (and even lower) prices also in cost based regimes as compared to incentive-based regimes.[8] Therefore, the second level instrument 'price regulation method' may play a less important role than the primary instrument of the political independence of the regulatory authority. Nevertheless, it should be noted that both variables are weak indicators for the real political processes and pressures.

The introduction of electricity exchanges increases the transparency on the wholesale level by giving signals on current or future prices. These signals are reliable only if liquidity is sufficient. However, the consequences of creating spot and futures markets can be positive as well as negative for prices. Increased transparency can make collusion more easily exercisable.[9] On the other hand, if workable competition is in place, electricity exchanges will make coordination of production easier and lead to efficiency gains by advanced arbitrage.

3. Data and model specifications

Our data set includes information for nine South American countries over the observation period 1994 to 2007. Consequently, panel models are used for estimation. The general regression model in this article takes the following form.

$$y^{i,t} = \beta_0 + \sum_{1\le k\le 5} \beta_k {r_k}^{i,t} + \sum_{1\le l\le 3} \beta_l {z_l}^{i,t} + \varepsilon^{i,t} \qquad (1)$$

[7] Cf. Estache and Rossi (2005)

[8] Some examples are the United Kingdom and Poland. The cost based element in UK incentive regulation, p-naught, was stipulated on a very low level, so that part of the success of incentive-based regulation originates from the cost-based share (Dewenter and Malatesta (1997)). For Poland the following quote is instructive: "Although the Law [Polish Energy Law] does not mention directly the cost of capital, it makes clear that the energy prices are to allow necessary investments and in practice the cost of capital will have to be taken into account in setting and approving of energy tariffs." This led to last year's discussion between the regulatory agency and distribution system operators whether or not cost of capital of old assets can be included into the cost base. The regulatory agency wanted to include solely the depreciation share of capital costs.

[9] Cf. again the experience in Britain described in Newbery and Pollitt (1997).

Different variables are chosen as the left hand side variable $y^{i,t}$. The first regressions use industrial end user prices (net of the state induced price share) to compare different model specifications. In a second and third approach, residential prices and the difference between residential and industrial prices are taken as explained variable. The results of the industrial customer group shall be mirrored against the ones of the residential customer group to see whether both groups are equally affected by reforms and finally the price difference is used to examine whether redistribution takes place as a consequence of reforms.[10]

In order to check the robustness of specifications for industrial customers, endogenous models with first lags and first-difference models are estimated. These are then also applied for residential end use tariffs and the estimation of price differences, given their superior statistical properties.

The price data we use is obtained from OLADE, a statistical office gathering data for the South American sub-continent. Prices are published for different customer segments. We use real exchange rates instead of power purchasing parities (PPP) to standardise prices in the respective countries. There is a trade-off in the choice between the two: The proliferation of a substantial part of inputs (assets) underlies world market conditions. Thereby, using PPP exchange rates would give a wrong impression of the competitive potential of a market, because prices in low-price countries tend to be overestimated and vice versa. By contrast, real exchange rates underestimate the share of costs resulting from country-specific (labour-intensive) inputs. To correctly consider this difference, one would have to standardise cost shares separately. Given the availability of (accounting) information this is rather wishful thinking. Considering the various customer groups, PPPs seem to be more adequate for residential customers who cannot move. However, from the perspective of a company, which is free to choose its production site and uses electricity as an input, electricity prices in real terms are the appropriate measure of comparison. In view of the relevant input factors as well as the (potential) mobility of the considered customer groups, the preference is given to price standardisations using real exchange rates.[11,12]

The right hand side variables remain more or less the same for the different regressions. In the dynamic regressions, all of them enter with their first and second lags. For the robustness check and in the remainder, first difference models are used.

Exogenous variables can be subdivided in variables $r_k^{i,t}$ describing regulatory reforms („reform variables" for short) and control variables $z_l^{i,t}$. The five reform variables are ownership unbundling *ou*, third party access *tpa*, privatisation *priv*, the introduction of electricity exchanges

10 A preference is given to industrial before residential prices for the comparison of different model specifications as a higher sensitivity to changes is expected in this segment.

11 For a deeper discussion of this topic, see e.g. overviews by Rogoff (1996) and Taylor (2002). For international price comparisons dealing with this topic see Ong (1997), Lutz (1999) and Productivity Commission (1999). For a price comparison in the telecommunication sector see Charles River Associates (2002).

12 Exchange rates and different countries' inflations are obtained from the World Bank database. All currencies are transformed to US$ and expressed in year 2000 values.

iee and independent regulatory agencies *ira*.[13] Except for privatisation, all of the reform variables are simple dummies. Privatisation is a compound variable of separate dummies for generation, transportation infrastructure and supply level privatisation, with all supply chain privatisations entering at equal weight and the result normalised to unity.[14] Reforms in our data take place at the date of legislative enforcement, meaning formal implementation with the exception of electricity exchanges, because here dates of actual implementation are easily verifiable. For all of the former variables, some observation error is inevitable. For example, effective implementation can be delayed as compared to formal implementation. Also, it is difficult to trace the date of actual implementation as processes are often highly structured (with sometimes strong effects resulting from small steps) and some arbitrary judgement may occasionally be needed to define whether a certain degree corresponds to full implementation. Hence, incorporated judgement and classification in the construction of regulation variables will lead to a certain measurement error.

Other sources for error-in-variables problems are varying conditions in the economic environment. E.g. the effects of the introduction of unbundling will strongly depend on the production structure at that time. A monopolistic or tight market will need much longer to profit of an unbundled regime than a market with a fragmented structure. The use of variables accounting for all such eventualities is fairly impossible against the background of data restrictions. Also an omitted variables problem may be relevant. This might lead to inconsistency and a bias of coefficient estimates. An example is an idiosyncratic and invariable production structure correlated with some regulation path. For example the potential of countries to build cheap water power plants is restricted by environmental conditions. Such factors are difficult to consider, but the employed panel estimation framework with country and time specific fixed effects will mitigate some of the omitted variables bias.[15] Country-specificities are e.g. the production structure or different quality of service levels. The full set of time dummies instead of a trend variable is used to account for macroeconomic shocks and special common influences to all countries, e.g. technological change. In addition to these fixed effects, the gross domestic product is used as a control variable. Hausman tests also strongly indicate the use of country-specific dummies.[16]

Multicollinearity only seems to be a problem for the dynamic regression in absolute values, which is examined in the following chapter. Consequently, the results of this regression have to be interpreted with care. [17] In the subsequent chapter 6, the results obtained for industrial

[13] Liberalisation and end price regulation as two other very important reform variables were excluded due to insufficient variation in the observation period. Industrial customers were mostly liberalised whereas residential customers remained mostly in not-opened markets. The same accounts for regulation of end prices.

[14] Third party access usually comes along with some form of unbundling. So, our third party access variable can also be seen as a rest-group variable comprising all forms of unbundling except ownership unbundling.

[15] This simpler model specification is given preference over generation shares as they have been used by Steiner (2000) and Hattori and Tsutsui (2004). Against the background of high water proportions in generation and heterogeneous levels across countries, additional variables considering e.g. stronger weather influences on prices would have to be included. To correctly model price formation processes, further factors and endogenous decision processes would have to be included. As this would lead to substantial complication, we hope that fixed country effects cause less distortion than solely modelling shares of water generation capacity. This could be a direction for future research.

[16] All assumption tests and model specification tests can be obtained from the authors upon request.

[17] Variance inflation factors above 10.

customers in chapters 4 and 5 are compared to the results of residential customers. The analysis is restricted to exogenous and endogenous variants of the extended Anderson-Hsiao estimator. This accounts for the models examining the evolution of differences of residential to industrial prices in chapter 7 as well. Concerning the other usual tests of standard assumptions, heteroscedasticity tests (Goldfeld-Quandt) showed very high significance. Therefore, heteroscedasticity consistent covariances are used. Non-stationarity does not seem to be a problem.[18] Table 1 summarizes the variables used in the different statistical specifications. The variables of interest are listed including their possible – positive and negative – main impacts on retail prices. The column 'empirical evidence' gives a first assessment of the variables in the literature so far. The last column, the expected overall impact, mirrors a subjective expectation about the impact on retail prices that shall summarize insights gained through empirical facts and by theoretical reasoning.

Table 1: Variables

Variable	Impacts on retail price		Emp. evidence	Exp. overall impact
	+	-		
Dependent variable				
Retail prices				
Reform variables				
Ownership unbundling	capital cost (risk), restructuring costs	increased competition	mixed	positive or negative
Third party access	restructuring costs (low)	increased competition	positive	negative
Privatisation	allocative inefficiency (profit target)	control by private owners	mixed	none
Implementation of electricity exchange	capital cost (risk) by increased transparency	arbitrage by price transparency	mixed	positive or negative
Independent regulatory authority	costs of additional transactions	less regulatory capture	positive	negative
Control variables				
Country and year dummies				dependent on shock
GDP per capita				dependent on relation of specific to general supply-demand ratio

4. Results

The estimates of the industry price regressions in absolute terms are reported in columns (1) and (2) of Table 2.[19] The signs of the reform variables are within reasonable bounds. Ownership unbundling seems to have the strongest influence on end user prices. The coefficient is significant at the 5% level and negative. Following these results, ownership unbundling would have an immediate price decreasing influence of 2 US-cent per kWh. The introduction of an electricity exchange is highly significant at the 1% level and would by contrast have a positive impact on industrial end user prices. All other reform variables are by contrast not significant.

These results are somewhat surprising. Ownership unbundling comes along with high costs in restructuring periods, whereas third party access would avoid the costs of unbundling but is expected to have a similar potential of cost reduction if tight supervision is exerted by a regulatory authority.

[18] Tested by Augmented Dickey Fuller with negative results.
[19] Country-specific effects are not reported, because they are not the primary concern of this analysis. It should be noted that they are significant at the 1% level.

The extension to a dynamic model (column 2 in Table 2) reveals some instability of the results. The ownership unbundling coefficient switches signs and has a similar effect, but into the opposite direction (although not significant). In addition the third party access variable is significantly positive at the 5% level, which is still as unexpected as in the first regression. All other reform variables turned in sign. Nevertheless, second lags of both variables reveal an interesting finding: Their coefficients are substantially negative, ownership unbundling even at the 1% level, which in principle illustrates the dynamic nature of the reforms. It would be premature to draw conclusions at this point as multicollinearity seems to be an issue in this regression (cf. above). The obtained results should not be overvalued and have to be checked for robustness. Also, although the estimation considers heteroscedasticity and AR-processes, Durbin-Watson statistics are still bad. This can probably be attributed to multicollinearity in the variables, too.

5. Robustness

To assess the robustness of the results in the previous section, two models in first differences are estimated (cf. columns (3) and (4) of Table 2). Differencing helps to overcome much of the multicollinearity problems. Further, country-specific effects vanish because of differencing. Nevertheless, we take a full set of time-dummies,*t*. The constant in this model therefore restricts to indicating a time-independent (average) trend.
Firstly, the exogenous model of the form

$$\Delta y^{i,t} = \beta_0 + \sum_{1 \le k \le 5} \beta_k \Delta r_k{}^{i,t} + \beta_l \Delta z_l{}^{i,t} + \beta_t t + \Delta \varepsilon^{i,t} \tag{2}$$

is estimated.

Secondly, a similar model extended for first lags of the left hand side variable is examined. The underlying implicit hypothesis is that prices partially move independently of observed fundamental changes and remain on similar levels as in the preceding period.

Table 2: Regression estimates and summary statistics

	absolute values			first differences							
	(1) dep. var. $p_{ind,t}$	(2) $p_{ind,t}$		(3) dep. var. $d1\_p_{ind,t}$	(4) $d1\_p_{ind,t}$	(5) $d1\_p_{res,t}$	(6) $d1\_p_{res,t}$	(7) $d1\_p_{diff,t}$	(8) $d1\_p_{diff,t}$		
indep. var.			indep. var.								
C	4,790 ***	4,614 ***	C	-0,045	-0,046	0,198	0,211	0,243	0,267 *	p_{ind}	industrial prices
$p_{ind,t}$	(-)	(-)	$d1\_p_{ind,t-1}$	(-)	-0,050	(-)	(-)	(-)	(-)	p_{res}	residential prices
$p_{res,t}$	(-)	(-)	$d1\_p_{res,t-1}$	(-)	(-)	(-)	-0,155	(-)	(-)	p_{diff}	diff. of res. to ind. prices
$p_{diff,t}$	(-)	(-)	$d1\_p_{diff,t-1}$	(-)	(-)	(-)	(-)	(-)	-0,246 *	ou	ownership unbundling
ou_t	-2,026 **	2,522	$d1\_ou_t$	3,462 ***	3,544 ***	4,605 ***	4,722 ***	1,142	0,925	tpa	third party access
tpa_t	1,204	2,613 **	$d1\_tpa_t$	-0,317	-0,179	1,299	0,840	1,616	0,201	priv	privatisation
$priv_t$	0,266	-0,118	$d1\_priv_t$	0,128	0,076	0,350	0,079	0,222	0,050	iee	intro. of elec. exchange
iee_t	1,084 ***	-1,940	$d1\_iee_t$	4,940 ***	4,936 ***	2,991 **	3,246 **	-1,949	-1,524 ***	ira	indep. reg. authority
ira_t	1,585	-0,269	$d1\_ira_t$	-0,292	-0,422	0,821	0,646	1,112 ***	1,480	gdppc	GDP/capita
$gdppc_t$	0,000 ***	-0,001 **	$d1\_gdppc_t$	-0,001 ***	-0,001 **	-0,001 **	-0,001 **	0,000	0,000		
ou_{t-1}	(-)	-1,447	$d1\_ou_{t-1}$	-1,282 *	-1,219 *	-1,001	-0,396	0,281	0,931		
tpa_{t-1}	(-)	1,889	$d1\_tpa_{t-1}$	-3,571 **	-3,531 **	-2,901 **	-2,568 *	0,669	1,003	*	0,90 significance level
$priv_{t-1}$	(-)	-0,006	$d1\_priv_{t-1}$	0,176	0,178	0,425	0,343	0,250	0,107	**	0,95 significance level
iee_{t-1}	(-)	1,768	$d1\_iee_{t-1}$	2,162	2,206	-0,678	-0,530	-2,840 ***	-2,821 ***	***	0,99 significance level
ira_{t-1}	(-)	0,635	$d1\_ira_{t-1}$	-4,220 *	-4,298 ***	-2,599	-2,796	1,620	1,697		
$gdppc_{t-1}$	(-)	0,000	$d1\_gdppc_{t-1}$	0,001	0,001	0,002 **	0,001 **	0,000	0,000		
ou_{t-2}	(-)	-4,174 ***	$d1\_ou_{t-2}$	-2,348 ***	-2,391 **	-4,928 ***	-4,976 ***	-2,580 ***	-2,445 ***		
tpa_{t-2}	(-)	-2,307	$d1\_tpa_{t-2}$	-3,258 *	-3,212 *	-0,350	-0,385	2,908 **	2,625 ***		
$priv_{t-2}$	(-)	0,948	$d1\_priv_{t-2}$	0,400	0,418	-0,234	-0,146	-0,634	-0,587		
iee_{t-2}	(-)	1,197	$d1\_iee_{t-2}$	1,537 ***	1,509 ***	1,804 ***	1,894 ***	0,267	0,551		
ira_{t-2}	(-)	0,678	$d1\_ira_{t-2}$	-0,031	-0,012	0,335	0,092	0,366	-0,114		
$gdppc_{t-2}$	(-)	0,001	$d1\_gdppc_{t-2}$	-0,001	-0,001	0,000	0,000	0,000	0,000		
R-squared	0,26	0,56		0,50	0,50	0,58	0,59	0,53	0,57		
Adj. R-squared	0,11	0,37		0,26	0,25	0,37	0,38	0,31	0,34		
S.E. of regression	1,92	1,62		1,26	1,27	1,23	1,23	1,21	1,18		
F-statistic	1,77	2,93		2,08	1,98	2,83	2,82	2,38	2,55		
P(F-statistic)	0,06	0,00		0,01	0,02	0,00	0,00	0,00	0,00		
mean dep. var.	5,88	5,88		-0,14	-0,14	0,12	0,12	0,26	0,26		
S.D. dep. var.	2,04	2,04		1,47	1,47	1,56	1,56	1,46	1,46		
SSR	273,87	163,30		86,32	86,05	81,90	79,55	79,41	74,05		
Durbin Watson	0,65	0,84		1,93	1,86	1,97	1,85	2,06	1,76		
Second stage SSR	273,87	163,30		86,32	86,05	81,90	79,55	79,41	74,05		

The regression takes then the following form.

$$\Delta y^{i,t} = \Delta y^{i,t-2} + \beta_0 + \sum_{1 \le k \le 5} \beta_k \Delta r_k{}^{i,t} + \beta_l \Delta z_l{}^{i,t} + \beta_t t + \Delta \varepsilon^{i,t} \qquad (3)$$

In general, the difference between the two specifications without and with lagged endogenous variables is not very pronounced. Coefficients in both models are more or less identical, solely some significance levels change although all of the significant variables remain significant and insignificant variables remain insignificant.

Compared to the results of the regression in absolute values, some noticeable changes occur. There is still a difference between short-run and long-run effects of ownership unbundling with immediately increasing prices and price reductions in the following two periods, yet now all these influences are significant. Furthermore, in both models the two contrasting impacts level out over the three periods. This suggests that ownership unbundling has no significant net effect in the long run when dynamic specifications are used.

This is confirmed by the corresponding Wald test, which fails to reject the restriction hypothesis of an influence of ownership unbundling on retail prices different from zero.

Third party access, on the other hand, has the ex ante expected negative signs for all of the three periods and is significant at 5% and 10% levels in the first and second lags. As the third party access variable goes along also with possible alternatives to ownership unbundling, a strict regulatory oversight accompanied by 'softer' forms of unbundling seems to be sufficient for a significant impact on end user prices and restructuring ownership by contrast provides no extra benefit. The analogous Wald test confirms a significant influence at the 95%-level. Privatisation is found again to be irrelevant for end user price level as in the models before. By contrast the possibility to trade electricity over an exchange seems to increase prices for industrial customers immediately and substantially. The influence of lagged periods is weaker, but stays positive and is also significant for the second lag. Another important change is observed regarding the implementation of independent regulatory authorities. The first lag coefficient is significant and exhibits a negative influence. The oversight by an independent regulatory body consequently shows price-decreasing impact on industrial prices. Joint Wald restriction tests identify overall influences different from zero exactly for the independence of the regulatory body and the introduction of an electricity pool.

In both models, Durbin-Watson tests indicate that the AR-problem has vanished. Inclusion of further lags did not lead to a better fit.

6. Residential prices

Competition in the residential customer segment is usually less intense than in the industrial segment. It is therefore possible that reforms give an occasion for a reallocation of costs and a redistribution of welfare from less competitive residential to industrial customers. Moreover the residential customer segment remains often temporarily or permanently protected during liberalisation processes. Notably in South America, liberalisation did not take place on residential markets during the period of observation and end price regulation was upheld. Especially the latter exhibits a great influence on retail prices which should not be overlooked when interpreting the results.

Therefore, price changes triggered by reforms are more likely to occur in the industrial segment. Spillovers to residential customers may be relevant, but these are then second order effects for residential customers. Results of these regressions are depicted in columns (5) and (6) of Table 2.

Taking a look at the coefficients of the ownership variable, the effects are rather similar to those observed for industrial customers. However, price changes take place on a higher price level. Analogously to industrial customers, effects level out between the significant unlagged and twice lagged ownership unbundling variables. For third party access for residential customers the results for industrial customers are also paralleled but underlie a dampening effect. This is as expected. The same holds in summa for the introduction of market places whereas the independence of the regulatory authority shows no impact in the regressions.

7. Distributional consequences

To use absolute residential-industrial price differences instead of ratios has the advantage that redistribution in absolute terms is measured instead of relative changes. As a consequence, real distributive effects of reforms are assessed. Again, models (2) and (3) are estimated. Columns (7) and (8) of Table 2 contain the results.

Ownership unbundling apparently leads to the unexpected result of favouring residential customers. Delving into the different respective effects of unbundling on industrial and residential prices as determined through the previous models rather indicates a total effect close to zero for both groups. The apparent inconsistency between these two results reduces, if the significant effect of the twice lagged unbundling variable in the last model is not considered in isolation but together with the insignificant but positive effect of the unlagged variable. Third party access leads to greater gains by industrial customers. Whereas both groups profit approximately equally the year after the reform, industrial customers leave residential customers behind in the second year after the introduction of third party access.

Privatisation plays again no role. The redistributive impact of market places tends to favour residential customers. Unlagged as well as once lagged coefficients show negative signs. The inclusion of the lagged endogenous variable leads to a high significance of the unlagged coefficient. The lagged coefficient is significant at the 1% level.

In contrast, industrial customers appear to profit more than residential customers of the independence of the regulatory authority. The unlagged coefficient is significant at the 1% level. The significance of the constant suggests that there may exist an autonomous process of redistribution independently of fundamental cost data and competitive behaviour. The positive sign of the coefficient means that the spread between residential and industrial prices is gaining in importance. In other words, the price difference between the two groups continually increases over the sample period. However, also the included lagged endogenous variable is significant at the 10% level reducing somewhat the importance of these relative price movements. This may be attributed to price regulation in connection with regulatory capture/interest groups or simple exercise of market power as a reaction to increasing competition for industrial customers, because residential customers are not able to switch.

8. Single market in South America

An aspect relevant for the well-functioning of super-national energy systems is the possibility of arbitrage between different countries. When a shock occurs, arbitrage should make a leveling-out of different price levels possible. Of course, as transportation capacity to connect different national electricity systems comes at a certain cost and thus is relatively scarce, it is likely that some congestion will remain. Theoretically the optimum is reached, when additional benefits of arbitrage just correspond to capacity extension cost. If power producers and transportation companies are not identical, incentives for increasing connector capacity investment may be limited: Grid companies earn money from congestion, generation companies earn money from high price levels resulting from congestion. As a result, firstly, generators from a low-price region will have few possibilities for grid capacity extensions to deliver to a high-price region, secondly, transportation companies earn from the price difference between low-price and high-price regions. This may result in persistent differences in prices at national or regional level. At first sight, the evolution of residential and industrial retail prices in South America during the observation period suggests a rapprochement to more cost-oriented prices at country-level.

Fig. I shows that at the beginning of the observation period, industrial retail prices have been on average even higher than residential retail prices. This is not in line with cost considerations, as residential customers are connected to the hierarchically lowest level of the network and thus should bear correspondingly higher costs. During the observed period, this has changed and residential retail customers have experienced a slight price increase whereas industrial retail customers have faced decreasing prices. In addition to the (marginal) analysis of the previous chapters, this look at the relative levels of residential and industrial prices provides a clear indication for the pressure of regulatory policy reform on prices to move towards costs.

The other question to be answered is whether the South American societies are able to benefit from a single continental market. This can be answered by analyzing the convergence of national price levels. Variance coefficients, $VC^{i,t} = E\left[\left(\left(\frac{1}{n}\sum_{i=1}^{n} p^{i,t}\right) - p^{i,t}\right)^2\right] \Big/ \left(\frac{1}{n}\sum_{i=1}^{n} p^{i,t}\right)$, are taken from residential and industrial prices. In the case of an emergence of a single market on the South American sub-continent, the dispersion of prices and thereby variation coefficients should decrease over time.[20]

The development of the variation coefficients shows a persisting substantial variance between prices in different countries (cf. Fig II). For residential as well as for industrial customers prices diverge at the beginning and towards the end of the observation period. There is only a period of about five years from the end of the nineties onwards with relatively similar price levels.

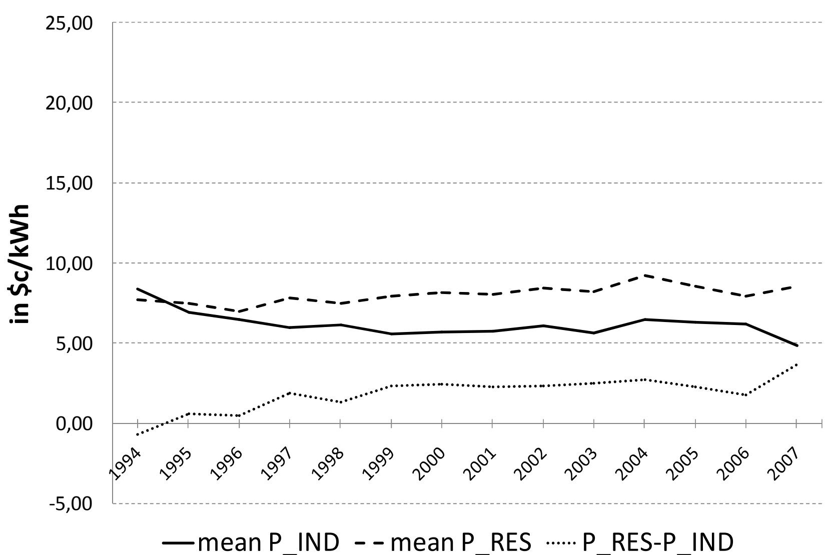

Figure 1: Retail prices

From this perspective trading barriers still are important, leading to substantial price variation between countries without possibilities for efficient arbitrage.

[20] The shift in price levels does not affect the following results as the variation coefficient is scale invariant.

One might however argue that some exceptional events like the "El Nino"-phenomenon have been responsible for some of the higher variations in prices.

The third line in Fig II therefore demonstrates the effect of removing the three countries, which suffer such events to the greatest extent, and are characterized by the highest deviations from the group mean.[21] Then a downward sloping curve is observed and a statistical analysis also suggests that this trend is significant. This may lend to the interpretation that in an equilibrium state without extreme shocks a convergence of prices is observable.

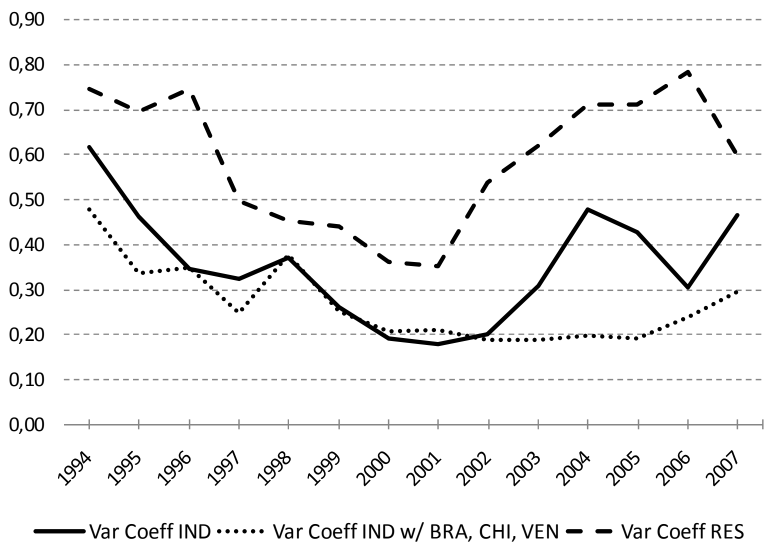

Figure 2: Variation coefficients

Nevertheless, the length of periods of large price differences is considerable. The standard deviation reaches levels higher than 30% of the mean of industrial prices in ten and higher than 40% in five out of fourteen cases. Deviations for residential customers even surpass this and reach levels of more than 70%.

Consequently one has to conclude that still substantial barriers to trade between South American countries do exist.

9. Conclusions

The major novelty of the approach chosen here is to examine the impact of energy regulation reforms including their dynamic effects.

One of the major conclusions for European regulators to be drawn from this analysis is the small overall effect of ownership unbundling. Price increases at the introduction stage are approximately equal to price decreases resulting from efficiency gains in the aftermath. Also, an important lesson is that third party access seems to have similar positive effects without having to incur high implementation costs at the beginning.

[21] These are Brasil, Chile, and Venezuela. Cf. also Appendix.

Further, privatisation appears not to be a cornerstone of the analysed reform processes. In none of the specifications the variable was significant.

Whereas the implementation of energy exchanges seems to show the true value (or cost) of the traded product by its impact to increase end user prices, the introduction of independent regulatory authorities has a (lagged) price decreasing effect on end prices.

As expected, the industrial customer segment has been much more affected by reforms than the residential customers. Somewhat surprising is the tendency of increasing residential prices during the observation period. However, various reasons may be invoked for this. For example, the price regulation process could have been influenced by regulatory capture or market power could have been used to raise residential prices as customers in this segment are not able to switch. This could lead to a subsidisation of industrial customers. Another interpretation could be more positive: Maybe, former subsidies to residential customers have been mitigated. Also, increased competition for industrial customers could have led to some sort of reallocation of costs. However, a certain redistribution of welfare from industrial to residential customers appears to have taken place.

Without being able to make a definite conclusion, it should be noted that a competitive environment for all customer segments is necessary to achieve optimal Ramsey-type price discrimination. Also, some countries in Europe still have problems in abolishing anti-competitive laws. Examples can be found in France with the regulated tariff TARTAM and in Germany with the recently introduced §29 of the competition law, which gives way to ex-post end user price regulation.[22] To allow for optimal arbitrage between South American countries, there still seems to be potential in connector capacity investment.

Extensions of the model framework used are imaginable. From a more detailed modelling of the power generation park to more sophisticated regression techniques there is still a wide scope for future research. Also, further analysis could focus on data sources, which allow an explicit analysis of impacts resulting from an abolishment of end user price regulation.

[22] Commission de Régulation de l'Energie (2009) and the German competition law, GWB (2008).

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APPENDIX

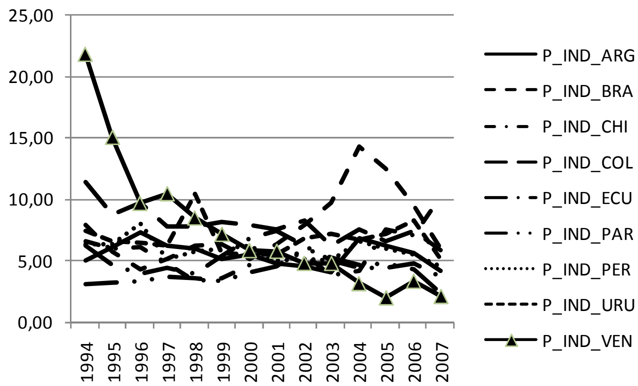

Fig. III. Industrial prices in $c, adapted for inflation.

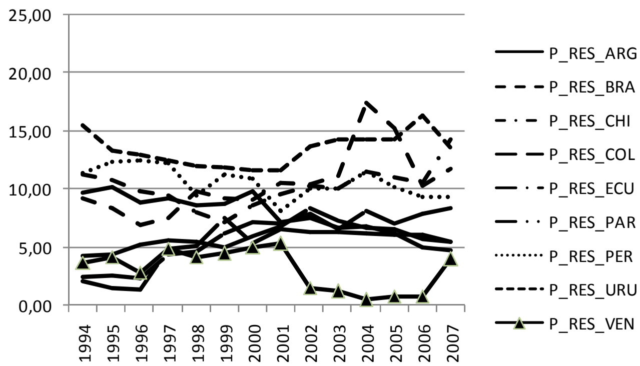

Fig. IV. Residential prices in $c, adapted for inflation.