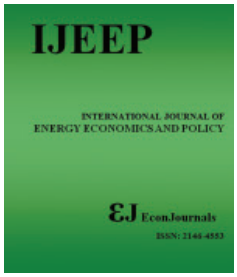

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Production Factors Use in the European Electricity Producing Companies During the Last Financial Crisis

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ABSTRACT

In the period from 2009 to 2012, the value added among the eight major European electricity producing companies on average oscillated around the stagnated trend. Between these companies there were large differences in organizational structure and technology of electricity production. Labor contributes to value added the most in European Data Forum (EDF) and Vattenfall, while capital contribution to value added is the greatest in Fortum and above average in GEN, Enel and CEZ. From 2009 to 2012 the contribution of labor on average increased, and the contribution of capital decreased. The single exception with opposite changes in production factors' contribution was Enel. Total factor productivity (TFP) is greatest in RWE, and this company improves it even at the cost of a decline in value added, employment and assets. At the other end from 2009 to 2012 EDF and Enel increased their TFP connected with value added growth. In terms of labor and capital engagement the European electric energy producing company adapts to the market. The elasticity of labor employment on final electricity consumption is 0.5, on the price of this energy for industrial use is 0.3, and on the labor costs per employee is −0.2. The elasticity of capital (assets) engagement is 0.8 on final electricity consumption, and 0.5 on the prices of electricity for industrial use (total Eurogroup).

Keywords: Industrial Organization, Electric Utilities, Energy, Energy Companies, International Comparision
JEL Classifications: L16, L94, Q43

1. INTRODUCTION AND SHORT THEORETICAL BACKGROUND

In this article we present how eight large European electric energy producing companies from seven European Union (EU) Member States responded during the current financial crisis. In doing so we focus on the dynamics of production factors engagement and the effects on the production function. First of all, we present economic-theory for our analysis, and then we outline the situation in the market, followed by an analysis of the response of the European ele ctricity producing company to market conditions by changing the demand for labor and capital, and an analysis of the strategic adjustment of eight European energy companies' production functions to the last financial crisis. The article concludes with the outline of the methodology, data sources, software used and literature. The main purpose of our research is to reveal the best practice in the process of large European energy company adaptation to significant negative change in its economic environment. The results presented in this paper contribute to understanding of electric power producer behavior during economic recession and after its transformation to market oriented enterprise.

In the market economy the volume of production of goods depends on the demand for these goods in the market. By adapting to the market, production must also adapt its demand for production factors: work, capital, raw materials, perhaps even patents. If we limit ourselves to evaluating only labor and capital, it is clear that their engagement in production depends on how much of these resources enterprises need to cover the market's demand. Given the technology and organization of production (in the medium term: a few years), the change in employment of labor (employment, dismissal) and engagement of

capital (investment, disinvestment) depend on the situation in the market of the commodity (Dornbusch and Fischer, 1984). If we take technology as given, then the demand for production factors (capital and labor) also depends on companies' assessments of how they are going to cover the production costs and reach the expected profit. This depends on the dynamics (growth or decline) in the prices of goods produced and sold by this company, as well as on the dynamic of marginal costs (for an additional unit) of employed labor and/or engaged capital. These costs are presented by salaries for employees and interest rates in the case of capital (the latter is not included in our analysis as we are limited to a period of very low and stable level of interest rates). The enterprise hires production factors to make products (goods or services); the process in which this takes place is called the "production." The concept of production, as it is used in economic analysis, has evolved gradually. The term production is of the Latin origin: producere for Romans meant to bear fruits and referred to the fruits of the land (Gilbert, 1987). The concept of production in the modern sense was defined by the physiocratic school of economic thought and especially by their leading author François Qesnay (Qesnay, 1759). The production function (the relationship between the size of the product and the combination of production factors involved in its creation) was first presented by a member of the Stockholm School of Economics - Knut Wicksell (Wicksell, 1901), and further elaborated by American mathematician Charles Cobb and economist Paul Douglas (Cobb and Douglas, 1928). They formed a function that connected the product with work and capital and even permit the assessment of differences in the economy of scale (changing the levels of work or capital cause different productivity outcomes of these factors of production - so we can distinguish growing, constant or diminishing returns on each additional unit of engaged labor and/or capital). This so-called Cobb–Douglas production function still did not allow the assessment of substitution (replacement) of capital with work or vice versa. Incorporation of this attribute to the production function developed later. Robert Solow made the first step in this direction (Solow, 1957) with the development of the CES production function, in which the Cobb–Douglas production function represents only the special case of a broader description of the possible combinations of work and capital in of production (Jorgerson, 1987).

Forming the Cobb–Douglas production function opened up another dimension. In addition to labor and capital the explanation of a given level of production also includes a constant. Robert Solow used it in his interpretation of economic growth (Solow, 1956). This constant in the Cobb–Douglas production function represents total factor productivity (TFP): a constant depending on the technology, organization, and perhaps other prevailing circumstances (such as natural conditions if they are not already included in the production as part of the engaged capital).

Solow's interpretation of the production function, in which the TFP is given to the economy from the outside, was later upgraded to include an additional production factor: human capital. The indicator of this production factor is commonly the number of years of schooling completed by employees or the volume of investment for R&D. Among the initiators of approach was Arrow (Arrow, 1962), while it was codified in endogenous growth theory by Romer (Romer, 1986). In this way TFP became the result of economic decisions about the engagement of human capital and how the economy works. In analyzing the responses of European manufacturers of electrical energy to the last financial crisis we used Solow's calculation of TFP (Gal, 2013) as an indication of the relative success in the adjustment to changing external circumstances. In our analysis we consider all the companies involved in the analysis to be large and that their production function is subject to the law of large numbers. The same law applies to the Cobb–Douglas production function and to Solow's approach to TFP. Some cases about efficiency in electricity production sector and TFP can also be found in Dogan and Tugcu (2015), Diewart and Nakamura (1999), Sahu and Narayanan (2011) or Maradin and Cerović (2014).

2. THE CONSEQUENCES OF THE LAST CRISIS AND THE ENGAGEMENT OF LABOR AND CAPITAL IN THE EUROPEAN ELECTRICITY PRODUCING COMPANY

In our analysis of major European electricity producers' responses to the financial crisis after September 2008, we take into account European Data Forum (EDF) from France, Enel from Italy, E.ON and RWE from Germany, Vattenfall from Sweden, Fortum from Finland, CEZ from the Czech Republic and GEN from Slovenia. They are all operating in the EU electricity market, which is divided into different regional submarkets. The performance of a given electricity production company still strongly depends on the circumstances and the situation in its domestic market. All enterprises in our analysis fall between large companies with a high level of capital and/or employees. Such companies adjust to the market similarly as does an entire national economy. Individual specifics are hidden in the fluctuations connected with the general situation of the energy (in particular), national or global market.

Table 1 shows the growth rates of gross domestic product (GDP), final consumption of electricity and prices of this commodity for its use in industry (the greater part of total consumption). These are relevant variables describing the circumstances on the electricity market. In Table 1 we can see the slow growth of GDP in the EU after 2009 and even stagnation in 2012. From 2009 to 2012, EU GDP increased just by 3%. Between 2009 and 2012, final consumption of electric energy fluctuated and increased similarly to real GDP. Over the same period the electricity prices for industrial use increased by almost 14%.

The data on changing electricity production, number of employees, labor cost per employee, total labor costs, and the volume of assets

Table 1: GDP (in real terms), the final consumption of electric energy and its prices for industrial use in the EU (growth rates)

Variable	2010 (%)	2011 (%)	2012 (%)	2009-2012 (%)
GDP	2.0	1.6	0.0	3.3
Final consumption of electricity	4.7	−1.9	0.3	3.0
Electricity prices for industrial use	0.3	7.0	5.8	13.6

Source: Eurostat database (2009-2012), EU: European union

in eight European energy companies (EDF, Enel, E.ON, etc.) are presented in Table 2. Here we can see that the production of electricity in the average European electricity producing company fluctuated around a stagnant level, the number of its employees decreased by 6%, while labor costs per employee increased by almost 15% from 2009 to 2012. The total labor costs in this period in the average European electricity producing company fluctuated around a rising trend and increased by almost 8%. From 2009 to 2012, analyzed European electric power producers increased their assets by 3%. In 2011, they even slightly divested.

Tables 3-5 present the value added employment and assets for each of the analyzed European energy companies in the period 2009-2012. Table 3 shows the value added. We can see that over the entire period it decreased in GEN, E.ON, RWE and CEZ, while it increased (accompanied with strong fluctuation) in Vattenfall, Fortum, Enel and EDF. The data in Table 4 show that between 2009 and 2012 the number of employees increased in GEN and decreased in all other analyzed companies, most sharply in Fortum (−20%), E.ON (−15%), and Vattenfall and Enel (both by −10%). RWE, EDF and CEZ faced smaller declines in employment. Overall, some of the analyzed companies in the period between 2009 and 2012 invested while others divested. According to the data in Table 5, the volume of assets increased in GEN, Vattenfall, Fortum, Enel, EDF and CEZ. On the contrary, it fell in both German energy companies in our sample – E.ON and RWE. The assets in RWE fell by almost 6%.

3. FACTORS OF THE DEMAND FOR LABOR AND CAPITAL IN THE EUROPEAN ELECTRICITY PRODUCING COMPANY

We performed stochastic analysis (panel) on the growth rates of annual data from 2009 to 2012 to assess the influence of changes in the electricity market and labor market on the employment and volume of assets in our sample of eight large European electricity producing companies. The results are presented in Table 6. For the variables (their growth rates) included in our analysis, we performed the pool unit root test and rejected the hypothesis that these series are not stationary. We used cross-sectional weights to eliminate or at least limit the impact of differences in the size and influence of other specifics of national economies[1].

1 About the methodology and data sources. How different energy and labor market variables influence the dynamics (growth or decline) in engagement of labor and assets in European energy companies was estimated by panel analysis (eight electric power producers). The results of our analysis are limited by time (2009-2012) and space (for eight large energy companies). The contribution of labor and capital as well as total factor productivity (Solow residual) was estimated by the Cobb-Douglas production function in logarithmic data (Gal, 2013). Our analysis covers the data for E.ON and RWE (both from Germany), EDF (France), Vattenfall (Sweden), Fortum (Finland), Enel (Italy), CEZ (Czech Republic) and GEN (Slovenia). The data on number of employees, labor costs, assets, output (sales and stocks) and material costs (spent for goods and services used), as well as the data on the structure of the electric power production (hydro, coal, etc.) were gathered from companies' annual reports (internal information: Vasja Kolšek, February 12, 2014). Value added is calculated as the difference between the companies' output and material costs. Data on final consumption of electricity and about the prices of this commodity for industrial use in the home countries of analyzed companies and the whole Eurogroup were obtained from the Eurostat Database.

Table 2: Production of electricity, employees, labor costs, assets in electricity producers (growth rates)

Variable	2010 (%)	2011 (%)	2012 (%)	2009-2012 (%)
The production of electricity	5.2	−7.0	2.4	0.2
Employees	0.1	−3.6	−2.7	−6.1
Labor costs per employee	5.7	2.1	6.3	14.7
Total labor costs	5.7	−1.5	3.3	7.6
Assets	1.0	−2.4	4.7	3.2

Source: Eurostat database (2009-2012)

Table 3: Value added (million €)

Year	Vattenfall	GEN	E.ON	RWE	Fortum	Enel	EDF	CEZ
2009	2426	150	18695	16928	3411	20174	27987	3722
2010	3226	105	18834	17724	3390	22161	27513	3848
2011	8202	135	15891	15274	3736	20577	27976	3610
2012	8115	119	16714	16001	3511	21021	29096	3412

Source: Companies' annual reports (2009-2012)

Table 4: The number of employees

Year	Vattenfall	GEN	E.ON	RWE	Fortum	Enel	EDF	CEZ
2009	36593	626	85108	70726	13278	81208	155072	32985
2010	38459	595	85105	70856	11156	78313	158764	32627
2011	37679	654	78889	72068	11010	75360	151804	31420
2012	33059	661	72083	70208	10600	73702	154730	31308

Source: Companies' annual reports (2009-2012), EDF: European data forum

Table 5: Assets (million €)

Year	Vattenfall	GEN	E.ON	RWE	Fortum	Enel	EDF	CEZ
2009	58177	655	156729	93438	19841	162331	240035	20036
2010	60146	680	152614	93077	21964	168052	240559	21696
2011	58675	720	140426	92656	22998	169891	231962	23190
2012	61567	714	152872	88202	24628	171656	250118	25301

Source: Companies' annual reports (2009-2012), EDF: European data forum

Table 6: The factors of demand for labor and capital (elasticity)

Variable	Employees	Assets
Constant	−0.0223, (−2.0)	−0.0133, (−0.5)
The demand for electricity		
The final consumption of electric energy	0.5269, (2.8)	0.8529, (2.4)
Electricity prices for industry		
The prices in the countries of origin of the manufacturer	0.2712, (2.4)	
The prices in the Eurogroup		0.5404, (1.4)
Wage rates		
Labor costs per employee in the company	−0.2383, (−2.2)	
R^2 (%)	42	63
DW	2.2	2.6

The results in Table 6 indicate the percentage change of employment or assets in the group of eight analyzed companies when the given explanatory variable (final electricity consumption, etc.) changes by 1%. Explanation of the dependent variable's variance is good (42% and 63%), having in mind that we are working on a panel and on data in the form of growth rates. T-values that present statistical significance of individual

independent variables' impact are shown in parentheses below the regression coefficients. DW statistics show that in our estimation there is no first-order autocorrelation. The results in Table 6 shows that a 1% increase in final electricity consumption effects a 0.5% increase in demand for labor and a 0.9% increase in demand for assets in the large European producers of electricity. And it applies, of course, also vice versa. A decline in final electricity consumption results in a contraction of the labor and assets in the electric energy producers that are forced to adjust to the changes in the market. A rise in electricity prices by 1% increases employment by 0.3% and assets by 0.5%. The growth of prices shows the producers that they will be able to cover the increased costs. European electricity producing companies make decisions about employment in accordance with circumstances on the domestic electricity market, and on the other side decide about assets engagement by taking into account the circumstances of the wider market (covering the whole Euro area). The decline of these prices indicates that producers will not be able to cover their costs and effects divestment and a reduction in employment. Finally, an increase in labor costs per employee by 1% lowers the demand for work (employment) by 0.2%. And vice versa, the reduction in labor costs per employee increases employment in these enterprises.

4. CONTRIBUTION OF LABOR AND CAPITAL TO VALUE ADDED AND TFP IN THE EUROPEAN ELECTRICITY PRODUCING COMPANY

For each of the analyzed companies and for each year of the observed period, we estimated the Cobb–Douglas production function to assess how much work and capital contribute to the companies' value added. The results are presented in Tables 7 and 8. Here we can see that the impact of work to the value added (an indicator of this contribution is the share of labor costs in the companies' value added) is relatively large (above 0.35) in EDF and Vattenfall, slightly smaller in RWE and E.ON, noticeably smaller (between 0.27 and 0.22) in GEN, Enel and CEZ, and the lowest in Fortum (only 0.16). We can conclude that there are large differences in technology and production structure among the observed companies. It is interesting to note that companies with a substantial share of thermal power plants (Table 9), and thus probably also coal mines with a large workforce, do not need an above average share of labor contribution to their production of electricity. CEZ, for instance, produces electric power with 50% share of thermal power plants, and its contribution of work to value added is among the lowest between the analyzed companies. It is also evident (Tables 7 and 9) that it is not necessary for electricity producers with a strong share of nuclear power stations to need a less than average share of labor contribution to their value added. EDF, for instance, produces electric power with a 76% share of nuclear power plants and ranks in first place in terms of the contribution of labor to value added among the analyzed energy companies.

The results in Table 7 also show that the contribution of the labor to the value added, estimated by Cobb–Douglas production function,

Table 7: The contribution of labor to value added → α_L

Year	Vattenfall*	GEN	E.ON	RWE	Fortum	Enel	EDF	CEZ
2009	0.99	0.18	0.28	0.27	0.15	0.24	0.38	0.18
2010	0.90	0.27	0.28	0.27	0.15	0.22	0.42	0.19
2011	0.33	0.23	0.37	0.34	0.14	0.21	0.39	0.19
2012	0.36	0.27	0.31	0.33	0.16	0.23	0.40	0.22

*Vattenfall labor costs in 2009 were almost the same as the whole value added which indicates the fact that company was in the process of reconstruction. In 2011 and 2012, the circumstances here apparently normalized, EDF: European data forum

Table 8: The contribution of capital to value added → αK

Year	Vattenfall	GEN	E.ON	RWE	Fortum	Enel	EDF	CEZ
2009	0.01	0.82	0.72	0.73	0.85	0.76	0.62	0.82
2010	0.10	0.73	0.72	0.73	0.85	0.78	0.58	0.81
2011	0.67	0.77	0.63	0.66	0.86	0.79	0.61	0.81
2012	0.64	0.73	0.69	0.67	0.84	0.77	0.60	0.78

EDF: European data forum

Table 9: Sources of electricity generation 2012 (in % of total production)

Year	GEN	E.ON	RWE	Fortum	Enel	EDF	CEZ
Hydro	10.9	6.5	0	34.5	23.2	7.2	3.1
Thermo	0.3	66.1	79.8	33.5	57.6	15.3	49.9
Nuclear	88.7	21.8	13.5	32.0	14.0	75.5	44.1
Alternative	0	5.5	6.7	0	5.2	1.9	3.0
Total	100	100	100	100	100	100	100

EDF: European data forum

increased in almost all observed companies (excluding Vattenfall) in the period between 2009 and 2012. The exception is just Italian Enel, where the contribution of labor to value added in the same period decreased slightly.

According to the results in Table 8, EDF and Vattenfall have the lowest capital contribution to their value added (from 0.58 to 0.64) in our group of electric power producing companies. This contribution is slightly higher (0.67 and 0.69) in both analyzed German companies, RWE and E.ON. In GEN, Enel and CEZ the capital contribution to value added (from 0.73 to 0.78) exceeds the average result in our sample. Among our selected electricity producing companies the capital contribution to value added is by far the largest in Fortum (0.84). From 2009 to 2012 the contribution of capital to value added in almost all of the analyzed companies (Vattenfall is not included) declined. The exception to this trend was Enel. Our estimations of the Solow residual[2] in the production function of analyzed electric power producers are presented in Table 10. These are in fact the estimations of the third factor, apart from labor and capital, contribution to companies' value added.

2 The impact of the "third" production factor to the value added of the eight European electricity producing companies was estimated with the Cobb-Douglas production function (Gal, 2013), and alternatively also with stochastic analysis. In doing so, we used two methods: classical regression analysis (OLS), which gives biased results when used in the estimation of the production function (Ornaghi and Van Beveren, 2012), and a newer method of Levinsohn and Petrin (Levinsohn and Petrin, 2003). All three methods rank the TFP in the analyzed companies the same. Due to the limitations of space, the results of alternative calculations are not presented in this article.

The results are presented for each company separately and for each year from 2009 to 2012. At the end of the analyzed period the TFP (the effect of the selected technology, organization, business model, economies of scale, etc.) was the largest in RWE (almost 0.2) and in the two Scandinavian companies: Vattenfall and Fortum (slightly over 0.16), followed by GEN and Enel (0.15 - close to the simple arithmetic mean of the analyzed companies' results), then EDF and E.ON (0.14), and at the bottom was CEZ (slightly below 0.13).

From 2009 to 2012, in the period after the beginning of the current financial crisis, TFP increased slightly in RWE, Enel and EDF; on the other side it sharply declined in GEN, E.ON, Fortum and CEZ. The increase of TFP in RWE was accompanied by the reduction of the company's value added, number of employees and assets. In the same period Enel and EDF improved TFP together with increasing their value added.

5. CONCLUSION

Our analysis of European electricity producing company deals mainly with the production of electricity and the response to market conditions. The elasticity of its employment is 0.5 for final electricity consumption, 0.3 for final electricity prices for industrial use, and −0.2 for labor costs per employee. Its elasticity of capital (assets) engagement is 0.8 for final electricity consumption, and 0.5 for final electricity prices for industrial use in the whole Euro area. In the period from 2009 to 2012 the value added of eight major European producers of electric power, on average, fluctuated around a stagnant level. There are noticeable differences in the structure and technology of electricity production among the analyzed companies. These differences are driven by investment decisions in previous periods, as well as with the different companies' business models.

For example, the German RWE optimizes its results with reduction in activity, assets and employment, while the Finnish Fortum increases its value added and replaces labor with capital. Cobb–Douglas production function estimations show that in EDF and Vattenfall labor contribution to the value added exceeds the results in the other analyzed companies and that the labor contribution in all electricity producers included in our sample, except Enel, moderately increased after the start of the last financial crisis. The labor contribution to value added in large European electric power producers cannot be explained via different use of natural sources (water, coal, nuclear fuel.) in this production. Among our electric power producing companies Fortum has the highest contribution of capital to its value added. This contribution is also above the average in GEN, Enel and CEZ. With the exception of Enel all other analyzed companies reduced the contribution of capital to their value added after 2009. In our sample of eight European electricity producing companies TFP is the largest in RWE and relatively high in Vattenfall and Fortum. After the start of the latest financial crisis TFP increased in RWE, EDF and Enel. This result was reached by a reduction of value added in RWE and oppositely by the growth of value added in EDF and Enel. There is strong policy implication of the results presented in this paper. They show that market works also in the case of electricity supply sector. The producers of this specific good are able and forced to adapt to the market conditions and in this process perform different strategies. Large market premiums, typical for the contemporary energy policies that support renewable energy sources, are going to distort the market with possible negative consequences for the stability and reliability of electric power supply.

Table 10: TFP

Year	Vattenfall	GEN	E.ON	RWE	Fortum	Enel	EDF	CEZ
2009	0.066	0.212	0.141	0.195	0.182	0.147	0.138	0.17
2010	0.08	0.14	0.145	0.205	0.171	0.156	0.136	0.164
2011	0.162	0.173	0.14	0.179	0.18	0.144	0.142	0.147
2012	0.165	0.15	0.138	0.196	0.163	0.149	0.141	0.129

EDF: European data forum, TFP: Total factor productivity

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