FIRM'S DEMAND FOR LABOR: DOES ENERGY EFFICIENCY MATTER?

by

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Abstract

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This work investigates the effect of energy efficiency on firms' labor demand. As more energy efficient firms have lower costs of production, such firms should be more competitive on internal and external markets, which should lead to higher level of production and, finally, to higher labor demand.

Using a Simultaneous Equation Model I reject the hypothesis about a positive relationship between energy efficiency and firm's employment level. Moreover, the average wage rate of a firm also tends to fall with an increase of energy efficiency.

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GLOSSARY

Energy efficiency. Fraction of total energy used by firm's equipment that is consumed in useful work and not wasted as useless heat.

Energy intensity. Energy use per worker (proxy for energy efficiency).

Identification problem. A situation when two theories are consistent with the same data.

Process innovations. Implementation of a new or significantly improved production or delivery method including significant changes in techniques, equipment and/or software.

Product innovations. The introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses.

Simultaneous equation model (SEM). A model in which the behavior of the several variables is jointly determined by two or more economic relations.

Chapter 1

INTRODUCTION

Governments of different countries are investigating ways of improving the energy efficiency of firms, households and public buildings. It is expected that such actions will benefit both the private and public sector because of lower CO2 pollution and the resources saved. More precisely, individuals and businesses that implement energy efficiency projects should expect to have considerable savings. Taken in aggregate this should lead to public benefit from lower carbon pollution and diminished overall energy demand, which translates to savings in energy generation.

In this work I am testing whether demand for labor is higher for more energy efficient firms. Intuitively, a more efficient use of energy by a firm will lead to the reduction of its production costs, which makes the firm more competitive at the internal and external markets. The latter, through the increased volume of production should result in additional job placements or increased wages (Roland-Holst, 2008). Analyzing whether improving the efficient use of energy is beneficial for the firm is crucial for several reasons. First of all, many sources of energy become more and more depleted, which leads to problems with energy supply. Second, the use of energy causes the emission of CO2, which exerts a bad influence on ecology as a whole and on climate changes in particular. Therefore, the inefficient use of energy pollutes our environment for no good reason, which means that any firm may reach the same level of output by using less energy resources on its production. However, the expected fixed costs that these firms should bear at the beginning of energy project implementation often are so high that only big or medium sized firms may find such projects beneficial, whilst smaller firms might think twice before making a decision. The choice of a firm usually depends upon the payback period of such projects (Härus, 2009).

For example, the US manufacturing firm Riverdale Mills Corporation is aimed at improving its competitiveness by reducing the energy intensity of its production. The cost of introducing a new energy efficient technology was $130 000, and cost reduction due to energy savings during the first year was $100 000. Consequently, with the pay-back period of 1,3 year the firm not only became significantly more competitive, but also could afford the increase in number of employers in order to enlarge its production[1]. In this paper, I evaluate the effect of energy efficiency improvements in firms on their employment and average wages, which will be used as indicators representing the firm's competitiveness and its market share.

The paper is structured as follows. In the second chapter the literature review is performed. The third chapter contains chosen methodology of the proposed analysis. The fourth chapter includes data description. In the fifth chapter the empirical results are discussed. And the last chapter provides conclusions and suggestions.

[1] National Association of Manufacturers (US)

Chapter 2

LITERATURE REVIEW

To become more competitive most of the firms try to get a larger share of market either by offering new products with unique qualities or by reducing costs of production, for example by shrinking firm's demand for inputs such as energy, and setting lower product's price. Overall, one may generalize all such firm's action under the denominator of the introduction of product and process innovations. However, in order to make this decision preferable to firms they should be aware of how it may affect the firm in terms of its size this sentence is not clear. In order to summarize such information, in this section I introduce review of articles that address the topic of innovation's effect on employment level.

The overview of relevant literature starts form theoretical approach to the issue combined with "general logic" relationships. Then I focus on the empirical studies that consider the effect of process and product innovations on firm's labor demand, simultaneously assuming that improving of energy efficiency is just a particular type of process innovations, so, the relationship between them and employment should be similar.

Energy inefficiency is not a new problem, so it is quite natural that it was frequently considered by scientists from the different points of view taking into account various aspects of economics. However, only article written by-Holst (2008) studies directly the effect of energy efficiency improvements on employment using econometric tools. In his paper he analyzed the energy use issue in California in the period 1972-2006 by using annual firm-level data. More precisely, he compared the historical employment growth with average wage rates and the level of energy efficiency in California over years. He concluded that increases in energy efficiency go together with employment increases.

Because of the lack of papers, and because energy efficiency projects can be considered as a specific type of innovation, this review will mostly scrutinize the articles about the relationship between employment, wage rate and innovations. Despite the fact that the effect of innovation on employment and wage was heatedly discussed by researchers from a theoretical point of view, the relationship between additional job placements, wage rate and innovations remains unclear. However, one can agree that the process and product innovations affect in a different way both employment and wage rate. A product innovation is the introduction of new products or at least a significant improvement of existing products. A process innovation is the implementation of new technologies which influence the cost of production. In this review the focus is made on the process innovations because they are more similar to energy efficiency projects. Moreover, the effect of process innovations on employment and wage rate is even more uncertain than of product innovations. On the one hand, implementation of a new technology may lead to a higher labor productivity, which means that the same level of output could be achieved by using less workers or by reduction of wage rate to the working people, but, on the other hand, this may also lead to a lower costs of production, increase of firm's competitiveness, higher demand on produced products and, finally, increase of job placements or average wage rate. So, the resulting direction of these effects depends upon their magnitudes. Consequently, there are two cases: the first, when all applied factors result in shift of demand curve of a firm for labor to the right (more workers and/or higher wage rate) and second, when demand curve for labor shifts to the left (less workers and/or lower wage rate).

Mathematically it may be represented in a following form:

$$CP=w*L+r*K+p*E \quad (1)$$

where CP is costs of production, w is wage rate, L is level of employment, r is cost of capital, K is the amount of capital that was used in production, p is price for energy and E is the amount of energy that was used in production.

Moving the level of employment to the left hand side we have:

$$L=1/w*(CP- r*K-p*E) \quad (2)$$

Taking the derivative of labor with respect to energy ($dL/dE= -p/w <0$) we get the direct effect of change in energy consumption on employment level taking all other factors constant. However, there exist several indirect effects of change in energy consumption on employment level. The first effect on employment goes through the effect of change in energy consumption on amount of capital in a firm ($dK/dE = -p/r <0$). The second one goes through the effect of change in energy consumption on firm's costs of production ($dCP/dE = p>0$). Moreover, the magnitude of resulting effect of change in energy consumption on employment and wage rate depends not only upon changes in cost of capital or energy but upon changes in firm's amount of labor due to changes in capital amount that also affect level of employment and wage rate ($dL/dK= -r/w<0$). So, as the predicted signs and the direction of possible changes in r and p are not clear, the direction of resulting effect is still ambiguous.

It is also worth indicating the importance of such factors as market structure and compensation mechanism, which indirectly influence the magnitudes of effects (Lachenmaier and Rottman,2006; Lachenmaier,2011; Harrison, 2005; Hall, 2006; Zimmermann, 2008).

All this uncertainty in theory increases the importance of empirical findings and explains the wide range of studies that consider relationship between innovations and employment since the late 80^{ies}. By looking at the type of data that researchers use, we may roughly divide them into three categories: cross-sectional analysis, analysis of short panel data (mostly for 2 years with a big

gap in time) and panel data analysis (Lachenmaier and Rottman, 2006; Lachenmaier, 2011). As the first two types of studies are typically the earliest ones (late 80ies and early 90 ies) and based mostly on low-quality data, the emphasis in this work is made on articles that use panel data analysis (starting from late 90ies).

Lachenmaier and Rottman (2006) analyzed a panel of German manufacturing firms (approximately 1500 yearly) for over 20 years from 1982 to 2004 by using the first-difference panel approach. As their main model they used static version of labor demand equation, where the change in labor demand is determined by the introduction of process and products innovations (separately), growth rate of the real hourly wage rate and growth rate of the Gross Value Added by sectors. Empirical results show that both types of innovations have positive and significant effect The advantage of this article is the large dataset for around 1500 firms which they use, but the drawback is that there are only manufacturing firms.

However, this problem was taken into account in the paper by Harrison and others (2005), where authors used the dataset of 19000 firms from France, Germany, Spain and Great Britain for 1998-2000 years. In this research they not only introduced the service sector in addition to manufacture sector, but also compared the estimated results between the four countries. They used an OLS approach, in which employment growth depends on rates of output growth of old and new products and controlled for process innovations and sectors. The main finding of this paper is that in manufacturing sector, process innovations have a negative effect on employment, while in the service sector this effect is smaller. However, the effect is the biggest (but still small) in Germany and insignificant in Spain and France.

Additionally, Hall and others (2006) using the same approach as Harrison provided an analysis for Italian manufacturing firms for 1995-2003 years and

found no significant effect from process innovations on labor, which can be explained by labor market rigidities, which probably exist in Spain and France.

Another approach to analyze this issue was performed by Zimmermann (2008), who used quantile regressions for data of German firms from 2003 to 2006 years. He found that process innovations have a positive effect on employment, but for growing firms the effect is larger.

As could be noticed all previous empirical studies were made for developed countries and even for them the results vary wildly. There are few studies for emerging economies (according to IMF classification). Merikull (2009) analyzed the effect of innovations on employment in Estonia. Using firm-level and industry-level data for 1994-2006 a positive and significant effect of innovations on employment was found. A possible explanation of such results is that for developing countries the marginal effect of innovations is much more beneficial than for developed countries.

All in all, in addition to previous empirical findings this research will add another determinant of employment growth – the level of firm's energy efficiency. Furthermore, in this paper I intend to study the employment and wage effects of innovations overall and energy efficiency projects in particular in almost 30 emerging countries.

Chapter 3

METHODOLOGY

In order to develop the methodology, with the help of which the main hypothesis will be tested, this chapter starts from a simple labor demand problem for the firm (Lachenmaier and Rottman, 2006; Zimmermann, 2008).

$$L=f(T,Q,X) \quad (3)$$

where L represents labor demand, T – technology that the firm uses in its production process, Q – quality of firm's products, X – other observable control factors. By taking logs this expression transforms into the next one, which is also known as the constant elasticity model because its beta-coefficients represent the elasticity between variables. The lower case letters represents here the log of capital letters.

$$l=b0+b1*t+b2*q+b3*x+e \quad (4)$$

It should be mentioned that the technology which the firm uses may be actually represented by the firm's process innovation activities. As the energy efficiency projects are in the focus of this work, this type of innovations will be separated from the group of process innovation projects. Moreover, the change in quality of products can be reflected by product innovation activities of the firm. It means that if a firm introduces new products or improves the existing ones, it increases the overall quality of the produced goods. Furthermore, the main variable that will represent control factors is the real hourly wage rate (Lachenmaier and Rottman, 2006). So, we have the following basic model (the lower script indices represent that we are also controlling for country, industry and year):

$$log(Empl_{ist}) = a0+a1*log(ProcessInn_{ist}) + a2*log(EnEff_{ist}) + a3*ProductInn_{ist} + a4*log(Wage_{ist}) + e \quad (5)$$

Where *Empl* – number of workers employed in a firm;

ProductInn – dummy variable that is equal 1 if a firm introduced in the last period new products or services, and zero otherwise;
ProcessInn – amount of investments on equipment;
EnEff – firm's energy efficiency level;

However, the set of variables that are present in this regression and influence the firm's demand for labor is not complete. For instance, such variables as the volume of sales, exporting status of the firm (share of sales that the firm exports abroad), the form of ownership (private, public ownership, etc.) also may affect the firm's level of employment. The more firm export goods abroad the more opportunities it has to increase its volume of sales, which needs more workers to produce these goods. The form of ownership may influence the level of employment through the special law restrictions or wage rate limitations. These conditions are different for each type of ownership.

Taking the above written information into consideration, we get the improved version of the previous model:

$$log(Empl_{ist}) = a0 + a1 * log(ProcessInn_{ist}) + a2 * log(EnEff_{ist}) + a3 * ProductInn_{ist} + a4 * log(Wage_{it}) + a5 * C + e \quad (6)$$

where C represents additional control variables such as the volume of sales, exporting status of the firm and the form of ownership.

But what is more interesting, if the firm already employs the optimal number of workers, instead of hiring additional persons, it will increase the wage rate for already existing people to motivate them to work more efficiently and more productively. Moreover, according to Helpman at al. (2011) firm wages and employment are similar power functions of firm productivity. So, improvements of energy efficiency affect both employment and wage rate on a firm. In this case, the above equation (6) will be slightly changed. Now the dependent variable is log of wage, while the main control variable is log of number of employees.

$$log(Wage_{it}) = c0+c1* log(ProcessInn_{ist}) +c2*log(EnEff_{ist}) +c3* ProductInn_{ist} +c4* log(Empl_{ist}) + c5 *C +e \quad (7)$$

However, according to Lachenmaier and Rottman (2006) employment also depends on wage rate. As the two theories are consistent with the same data, we have an identification problem (Green, 2000). There is a way of dealing with this problem - add more (but equation-specific) explanatory variables to each equation and use simultaneous equations model. These additional explanatory variables are in fact instruments for wage rate in equation (6) and instruments for the employment rate in equation (7).

So far, for the method of simultaneous equations we need IVs for the wage rate and employment. In the first case for this purpose may serve such variables as the experience that the top-manger has in a given sector (calculated as a number of years) and level of firm's competitiveness.

The more experienced is the top-manger the better he manages the firm that translates into better selection of other workers, which means that employers are placed in the positions that they fit best. Such top-manager not just receives higher wage, but also pay higher wages for the workers because they work relatively more efficient. Simultaneously, number of employees in a firm doesn't change, changes only their quality and productivity because of replacing employees for the better ones. So, the overall average wage rate is affected by the top-manager's experience, whilst firm's labor demand remains unchanged.

The higher level of firm's competitiveness the higher average quality of labor force it possesses, and this requires paying the higher average wage rate to the employers in order not to let them go to work to the competitors. It implies that mostly firm's wage rate is affected by the change of it competitiveness keeping the level of employment unchanged.

As an instrument for the employment level may serve such variable as the share of workers with higher education The higher share of well-educated workers firm has the better this firm operates, which means that it develops and grows faster improving the firm's size that is actually its level of employment. The firm's average wage rate stays unchanged because high wages for well-educated workers are compensated by the additional low-quality workers employed in the production that earn low wages.

All the written above may be presented in a form of the next SEM model:

$$log(Empl_{ist}) = a0 + a1 * log(ProcessInn_{ist}) + a2 * log(EnEff_{ist}) + a3 * ProductInn_{ist} + a4 * log(Wage_{it}) + a5 * C + a6 * X + e \quad (8)$$

$$log(Wage_{it}) = c0 + c1 * log(ProcessInn_{ist}) + c2 * log(EnEff_{ist}) + c3 * ProductInn_{ist} + c4 * log(Empl_{ist}) + c5 * C + c6 * Y + \quad (9)$$

where *Empl* – number of workers employed in a firm;

ProductInn – dummy variable that is equal 1 if a firm introduced in the last period new products or services, and zero otherwise;

ProcessInn – amount of investments on equipment;

EnEff – firm's energy efficiency level;

C –control variables such as volume of sales, exporting status of the firm, the form of ownership;

X – instruments for wage rate that consist of the share of top-manager's experience and the level of firm's competitiveness;

Y – instrument for the employment that consists of the share of workers with higher education.

Controlling for the industry, country and year in each model is essential due to fixed effects that these variables may absorb.. Also, the changes in employment and wage rates are expected to be different in different countries due to various natural resources endowments and demand elasticities for

energy. Controlling for year is required to eliminate the effect of overall development of the world's conditions.

As in the literature review section most papers estimate the effect of innovations on employment with the help of OLS regression, in this study except for the SEM model, which is believed to fit the theory in the best way, also OLS regressions are performed (simple and extended versions). The comparison of all models with the empirical results of other authors is also present.

To sum up, in this work 4 hypotheses are tested. First two of them are main hypothesis, while other two are auxiliary.

Hypothesis 1: Using the SEM model with BEEPS dataset the relationship between more efficient use of energy and firm's labor demand is positive.

Hypothesis 2: Using the SEM model with BEEPS dataset the relationship between more efficient use of energy and firm's average wage rate is positive.

Hypothesis 3: Using the SEM model the process innovations and level of firm's energy efficiency have similar effect on employment (either both positive or both negative).

Hypothesis 4: Using the SEM model with BEEPS dataset the effect of process and product innovation on firm's employment level is positive.

Chapter 4

DATA DESCRIPTION

The analysis uses the "EBRD-World Bank Business Environment and Enterprise Performance Survey (BEEPS)" data for 2002-2009 years being available publicly on the EBRD site. This source provides the information collected from firms of 29 different developing countries (for the last round in 2008-2009 years) from Eastern Europe and Central Asia. Moreover, BEEPS collect information from around 28 000 firms from different sectors.

The depending variables that are used in the SEM model can be easily extracted from the dataset. The employment level is characterized by the question "A the end of fiscal year, how many permanent, full-time employees did this establishment employ?", while the average firm's wage rate is described with the question "Total labor cost (including wages, salaries, bonuses, etc) in last fiscal year" divided on the employment level. Both variables are taken in the logarithmic form.

For the set of independent variables the linking to the questions is not always that straightforward. As there is no specific question in this data set that evaluates the level of firm's energy efficiency, the energy intensity per worker variable is used as a proxy for firm's energy efficiency. To construct the energy intensity variable there were used answers to the next questions: "Total annual cost of fuel in the last fiscal year" and "Total annual cost of electricity in the last fiscal year", and after summing the values of them, this variable was normalized with respect to firm's employment level and then taken in the logarithmic form.

The answers to the question "Total annual expenditures for purchases of equipment in the last fiscal year" divided on the firm's employment rate and then taken in the logarithmic form is used as a proxy for Process innovations

variable because it describes improvements of technology used in by a firm in the best way, and this is exactly what we call process innovations.

Product innovations variable is characterized by the question "Has this establishment introduced new products or services in the last three years?", which is a dummy variable (1 indicates that firm introduced new products, and 0 - didn't).

Exporting status variable is represented by the question "Percentage of establishment's sales: Direct exports"

The level of foreign and domestic competitiveness variables are taken from the questions "Effect on decision on production costs: pressure from foreign competitors" and "Effect on decision on production costs: pressure from domestic competitors" respectively. Both of them are dummy variables and include four levels of pressure from competitors, from the lowest to the highest level: not at all important, slightly important, fairly important and very important. The first level is pressure (not at all important) is dropped due to collinearity.

Answers to question "How this firm established?" represents the form of ownership variable (also dummy), which is divided on four types of ownership: private domestic firms, private foreign firms, state-owned firms and firm's with other forms of ownership. Dummy for private domestic firms is dropped due to collinearity.

Variable share of workers with higher education stands for the "Percent of employees at the end of fiscal year with a university degree" in the BEEPS questionnaire, while experience of top-manager variable stands for "How many years of experience working in this sector does the Top Manager have?" and volume of sales variable is represented by the question "In the last fiscal year, what were this establishment's total annual sales?" divided on the employment level and then taken in the logarithmic form.

Additionally, there is presented table in the Appendix that shows linkages between variables in my methodology part with variables in BEEPS dataset and questions on which this variables answer.

Simultaneously, there are several assumptions that should be explicitly stated:

Assumption 1: Firms spend money on new technology and equipment on a regular basis because technology continuously becomes outdated and equipment breaks down. Therefore, process innovation variable absorbs mostly short-run effects on firm's employment level and wage rate.

Assumption 2: The same is assumed for the product innovation variable. It means that firms constantly introduce new products or significantly improve existing ones, so the effect of product innovations on the dependent variables is also short-running.

Assumption 3: The effect of energy efficient technology on the dependent variables are assumed to be a long-running because it is calculated as the sum of costs of electricity and fuel normalized with respect to firm's employment level that basically represents firm's energy intensity level. So, the energy efficiency variable absorbs the effect of previously implemented energy efficient technology that is represented in the form of energy costs reduction.

Concerning the control variables (industry and country) the most represented of industries are food, clothing and other manufacturing industries, while the most represented country in this dataset is Turkey. However, the most interesting for us information (how much firm spend money on energy resources) is not given by most firms in the database. Moreover, not all firms revealed in the questionnaire other their characteristics that are used as independent variables. So, the actual sample that I use is far smaller than the whole dataset because of missing observations. This may cause sample bias problem. The attempt to figure out why not all firms answered these questions is performed below in this section.

The resulting sample consists of 1837 firms for which the summary statistics is presented in Table 1 at the right-hand side (restricted sample section). At the same time there is present summary statistics for the whole dataset, so it is quite easy to compare how the variables' means and standard deviations have changed. For example, in the restricted sample the average firm's size that is represented by the number of employers increased from the 118 to 154 workers per firm simultaneously reducing the standard deviation. However, the average wage rate among firms moved down as the spending on process innovations did. The distribution of firms with respect to product innovations has also slightly changed. In our sample the share of firms that introduces new products is almost 70%, while in the whole dataset it is only 43%. Moreover, the firms in the resulting sample are on average more energy intensive, but the share of sales that the firm exports increased (while the whole volume of sales decreased). The distribution of firms with respect to ownership hasn't changed much, though the shares of firms that feel high enough pressure from either domestic or foreign competitors increased.

Furthermore, the average share of workers with higher education significantly decreased, which indicates that probably in the sample larger share of manufacturing firms left that mostly use low-skilled workers in the production.

Table 1: Descriptive statistics

Variable	Whole dataset			Restricted sample		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Emplyment level	29214	118	752	1837	154	327
Wage rate	18127	1147319	8.37e+07	1837	561061	8858642
Process innovations	16300	1.04e+08	1.91e+09	1837	247436	2071381
Product innovations	27669	0.435	0.496	1837	0.692	0.462
Energy intensity	4826	101202	819067	1837	137171	1086899
Exporting status (% of sales)	29360	10	24	1837	19	31
Private foreign firms	29716	0.026	0.160	1837	0.031	0.173
State-owned firms	29716	0.005	0.067	1837	0.011	0.104
Other forms of ownership	29716	0.026	0.158	1837	.026	0.160
Experience of top-manager	13936	17	11	1837	17	11
Volume of sales	22541	1.30e+09	2.26e+10	1837	3998700	3.00e+07
Domestic competitors pressure (slightly)	29716	0.164	0.370	1837	0.199	0.399
Domestic competitors pressure (fairly)	29716	0.298	0.457	1837	0.327	0.469
Domestic competitors pressure (very)	29716	0.252	0.434	1837	0.302	0.459
Foreign competitors pressure (slightly)	29716	0.162	0.368	1837	0.188	0.391
Foreign competitors pressure (fairly)	29716	0.170	0.376	1837	0.231	0.422
Foreign competitors pressure (very)	29716	0.129	0.335	1837	0.228	0.419
Share of workers with higher education (%)	24629	3.188	7.487	1837	0.793	2.005
Number of countries	29			27		
Number of industries	21			16		
Years	2002-2009			2008-2009		

Also it is very interesting to look how the distribution of firms among our main control variables (year, country and industry) has changed. In the Table 2 we observe the comparison of firms' distribution with respect to the years of survey.

Table 2. Distribution of firms by year

	Whole DB		Sample	
Year	Freq.	Share	Freq.	Share
2002	6153	21%	0	0%
2005	10421	35%	0	0%
2007	1952	7%	0	0%
2008	3375	11%	552	30%
2009	7815	26%	1285	70%
Total	29716		1837	

After restricting sample by the availability of needed information there were left firms only from the last two years: 2008 and 2009. Hypothetically, in the first rounds firms wasn't ready to give such detailed information as the exact amount of money spent on fuel or electricity and so on because it didn't appear in the annual reports. Alternatively, these questions simply weren't asked in the earlier waves. Another explanation is that in the earliest years firms hadn't seen the importance of such questions for researchers, while in the last round this could have been shown by questioners on the example of previous waves of the survey.

Below Table 3 presents the distribution of firms with respect to the country.

Table 3. Distribution of firms by countries

	Whole DB		Sample	
Country	Freq.	Share	Freq.	Share
Albania	732	2.5%	7	0,4%
Armenia	896	3.0%	42	2,3%
Azerbaijan	900	3.0%	37	2,0%
Belarus	848	2.9%	37	2,0%
Bosnia	743	2.5%	61	3,3%
Bulgaria	1853	6.2%	39	2,1%
Croatia	1160	3.9%	19	1,0%
Czech Republic	861	2.9%	58	3,2%
Estonia	662	2.2%	57	3,1%
FYROM	736	2.5%	65	3,5%
Georgia	747	2.5%	30	1,6%
Hungary	1151	3.9%	42	2,3%
Kazakhstan	1379	4.6%	71	3,9%
Kyrgyz	610	2.1%	28	1,5%
Latvia	652	2.2%	53	2,9%
Lithuania	681	2.3%	50	2,7%
Moldova	887	3.0%	58	3,2%
Montenegro	154	0.5%	20	1,1%
Poland	2008	6.8%	59	3,2%
Romania	1396	4.7%	65	3,5%
Russia	2363	8.0%	252	13,7%
Serbia	900	3.0%	81	4,4%
Slovakia	665	2.2%	38	2,1%
Slovenia	687	2.3%	83	4,5%
Tajikistan	736	2.5%	32	1,7%
Turkey	2475	8.3%	275	15,0%
Ukraine	1908	6.4%	133	7,2%
Uzbekistan	926	3.1%	45	2,5%
All	29716		1837	

The overall pattern of firms distribution among countries hadn't changed very much. However, if in the whole sample the most represented countries are Bulgaria, Poland, Russia, Turkey and Ukraine that possess from 5% to 10% of the all firms, in the analyzing sample the share of such countries as Russia, Turkey and Ukraine significantly improves (13,7%, 15% and 7.2% respectively), which increases the inequality of firms' distribution among countries. All other countries are represented in less than 5% share of all firms.

The following on the next page Table 4 presents the distribution of firms with respect to the industry they operate in. There were 19 different industries in the dataset in which firms operate. All of them may be divided into two main categories: manufacturing and services. However, in order to better control for industry related fixed effects this variable wasn't modified. After restriction of the sample, one industry (IT) was omitted. However, it wasn't well represented in the whole dataset as well (only 2%). As was supposed somewhere above the restricted sample contain comparably higher share of firms from the manufacturing industries. For example, if in the whole data set the highest share of firms were from the retail sector (24.2%), the analyzed sector contains only 1.5% of such firms. On the contrary, the second most represented in the whole dataset industry – Food (10.6%) – becomes the most represented in the restricted sample (21.0%). The other sectors that are well-represented in our sample are Other manufacturing (17.7%), Garments (11.8%) and Fabricate and metal products (10.4%). All of them belong to the manufacturing group of industries.

Overall, the constructed sample is significantly different from the whole dataset. The observations from the early waves do not include information about our main variables and consequently were not used. Moreover, in the analyzed sample most of the firms from the service sectors as retail were deleted, while the share of manufacturing firms is significantly higher. So, the sample is quite unrepresentative.

Table 4. Distribution of firms by the industry

	Whole DB		Sample	
Industry	Freq.	Share	Freq.	Share
Other manufacturing	1055	8,0%	326	17,7%
Food	1392	10,6%	386	21,0%
Textiles	412	3,1%	104	5,7%
Garments	869	6,6%	217	11,8%
Chemicals	404	3,1%	129	7,0%
Plastics and rubber	209	1,6%	61	3,3%
Non metalic mineral products	323	2,5%	104	5,7%
Basic metals	110	0,8%	33	1,8%
Fabricate metal products	684	5,2%	191	10,4%
Machinery and equipment	630	4,8%	168	9,1%
Electronics	198	1,5%	45	2,4%
Constraction section	1025	7,8%	13	0,7%
Other services	359	2,7%	4	0,2%
Wholesale	969	7,4%	24	1,3%
Retail	3180	24,2%	28	1,5%
Hotel and restaurants	446	3,4%	2	0,1%
Transport section	612	4,7%	2	0,1%
IT	265	2,0%	0	0,0%
Total	13142		1837	

Chapter 5

EMPIRICAL RESULTS

Following the methodology part, the first regression estimated in this work is OLS regression, where dependent variable is employment and independent variables are product and process innovations, wage rate and energy intensity (Lachenmaier and Rottman, 2006). The estimation results are presented below in the Table 5 (middle column). As we see all variables of interest are significant except for Energy intensity variable.

The regression shows that if the firm introduces new products the firm's level of employment increases by 0.2%, but if firm increases spending on process innovations by 1% the employment falls by 0.082%. The increase of firm's average wage rate by 1% leads to the increase of employment by 0.101%. So, in this case the hypothesis about positive relationship between introduction of product innovations and employment level is accepted, while the hypothesis about positive relationship between process innovations and employment level is rejected. The firm's level of energy efficiency turned out to be insignificant. However, the results of this regression are biased due to omitted variables bias. More explanatory variables are needed.

The expanded version of OLS model (Table 5) takes into account other factors that influence firm's demand for labor. In this case (simultaneously controlling for volume of sales, share of exporting goods and form of ownership) the wage rate become also insignificant, while the results for product and process innovations are similar to the previous estimates. The introduction of new products by a firm leads to the increase of employment increases by 0.178%, and the increases of spending on process innovations by 1% results into fall of the employment by 0.085%. Energy efficiency is still insignificant in this model.

Table 5: OLS regressions

Independent variables	OLS (1) Emplyment level	OLS (2) Emplyment level
Product innovations	0.200**	0.178**
	(0.071)	(0.066)
Process innovations	-0.082***	-0.085***
	(0.022)	(0.021)
Energy intensity	0.003	-0.033
	(0.025)	(0.024)
Wage rate	0.101**	0.013
	(0.033)	(0.033)
Volume of sales		0.112***
		(0.031)
Exporting status (% of sales)		0.0157***
		(0.001)
Private foreign firms		0.129
		(0.174)
State-owned firms		0.731*
		(0.287)
Other forms of ownership		0.475*
		(0.186)
2009 year (dummy)	-0.942	-1.012*
	(0.543)	(0.509)
Constant	3.064	2.866
	(0.545)	(0.566)

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

Taking into account identification problem that arise in our case and is discussed in more details in the methodology part, the SEM regression should give us the most credible estimations because it eliminates endogeneity in the previous models. (Table 6)

In the employment equation product innovations turned out to be insignificant, process innovations on the 10%-level of significance positively affects employment. More precisely, 1% increase of spending on process innovations leads to the 0.54% increase of employment. What is more important, the energy efficiency variable in this model is significant. An increase of the firm's energy intensity by 1% (or reduction of energy efficiency by 1%) results into increase of employment by 0.624%. The wage rate in this equation negatively affects employment: increase if average wage rate by 1% leads to decrease of employment by 10% seems rather high.

The estimates of this model reject the hypothesis that process innovations and energy efficiency affect the employment in the same way. In fact, process innovations positively influence level of employment, whilst energy efficiency negatively. Moreover, the hypothesis about positive relationship between energy efficiency and employment is also rejected. Only the hypothesis about positive effect of process innovations on the firm's demand for labor is supported.

In the wage equation product innovations negatively affects wage rate (on the 10%-level of significance): introduction of new products leads to the decrease of wage rate by 0.091%. The process innovations and energy intensity variables are extremely significant in this equation and again affect the wage rate in a different ways. Increase of spending on process innovations by 1% leads to the increase of average wage rate by 0.08%, and increase or firm's energy intensity by 1% (or decrease of energy efficiency by 1%) results into increase of wage rate by 0.072%.

This equation estimates reveals the following information. The hypothesis positive relationship between energy efficiency and wage rate is rejected. So, the more energy efficient firms pay lower average wages. The product innovations have the same effect. However, process innovations positively influence wage rate.

Table 6: SEM regression

Independent variables	Emplyment level	Wage rate
Wage rate	-10.235*	
	(4.204)	
Emplyment level		0.295*
		(0.122)
Product innovations	-0.418	-0.091"
	(0.549)	(0.054)
Process innovations	0.540"	0.080***
	(0.301)	(0.018)
Energy intensity	0.624*	0.072***
	(0.316)	(0.018)
Volume of sales	2.957*	0.247***
	(1.200)	(0.027)
Exporting status (% of sales)	0.032**	-0.002
	(0.010)	(0.002)
Private foreign firms	1.438	0.124
	(1.380)	(0.131)
State-owned firms	5.214"	0.244
	(2.791)	(0.232)
Other forms of ownership	4.625*	0.291*
	(2.184)	(0.147)
Experience of top-manager	0.005	
	(0.012)	
Domestic competitors pressure (slightly)	-0.290	
	(0.411)	
Domestic competitors pressure (fairly)	-0.816"	
	(0.420)	
Domestic competitors pressure (very)	-0.573	
	(0.376)	

Table 6: SEM regression (Cont.)

Independent variables	Emplyment level	Wage rate
Foreign competitors pressure (slightly)	1.739**	
	(0.645)	
Foreign competitors pressure (fairly)	1.614*	
	(0.663)	
Foreign competitors pressure (very)	1.689"	
	(1.014)	
Share of workers with higher education (%)		-0.003**
		(0.035)
2009 year	-25.601*	-1.956***
	(10.592)	(0.421)
Constant	94.803*	7.899***
	(37.515)	(0.582)

t statistics in parentheses

" p< 0.1, * p<0.05, ** p<0.01, *** p<0.001

The validity of these estimates considerably depends upon the quality of chosen instruments. So, in order to be confident in our conclusions we should check the validity of these instruments. So as to do this we need the first stage regression of simultaneous equations model that is presented in the Table 7. Instrument for employment level (Share of workers with higher education) is significant on the 0.1%-level, so we conclude that it is good. However, for the wage rate only "pressure from foreign competitors"-instrument that is measured as 4 levels of pressure from competitors is significant. This is enough to receive the valid estimates, but there is still a lot of room for improvements.

Table 7: First-stage regression of SEM

	Emplyment level	Standard error	Wage rate	Standard error
Product innovations	0.176**	(0.064)	-0.041	(0.050)
Process innovations	-0.050*	(0.019)	0.121***	(0.015)
Energy intensity	0.013	(0.022)	0.112***	(0.018)
Private foreign firms	0.229	(0.167)	0.277*	(0.132)
State-owned firms	0.815**	(0.276)	0.385"	(0.218)
Other forms of ownership	0.364*	(0.179)	0.395**	(0.141)
Experience of top-manager			0.001	(0.002)
Domestic competitors pressure (slightly)			0.031	(0.076)
Domestic competitors pressure (fairly)			-0.089	(0.071)
Domestic competitors pressure (very)			-0.069	(0.073)
Foreign competitors pressure (slightly)			0.142*	(0.066)
Foreign competitors pressure (fairly)			0.191**	(0.064)
Foreign competitors pressure (very)			0.271***	(0.067)
Share of workers with higher education (%)	-0.296***	(0.015)		
2009 year	-1.284**	(0.490)	-1.450***	(0.385)
Constant	4.464***	(0.367)	10.909***	(0.292)

t statistics in parentheses

" p< 0.1, * p<0.05, ** p<0.01, *** p<0.001

Chapter 5

CONCLUSIONS

In the competitive markets all firms try to get a larger share of market either by offering new products with unique qualities or by reducing costs of production, for example my shrinking firm's demand for inputs such as energy, and setting lower product's price. Overall, one may generalize all such firm's action under an issue of introduction of product and process innovations. However, in this article we consider the effect on firm's energy efficiency improvements as a particular type of process innovations that a firm may implement. In order to make this decision preferable to the firms, the last ones should be aware of how it may affect the firm in terms of its size and its influence on average wage rate.

Using a Simultaneous Equation Model model I reject the hypothesis about the positive relationship between energy efficiency and firm's employment level. Moreover, an average wage rate on the firm also falls with the increase of energy efficiency.

Also there were rejected the hypothesis that process innovations and energy efficiency affect the employment in the same way. In fact, process innovations positively influence level of employment, whilst energy efficiency negatively. The hypothesis about positive effect of process innovations on the firm's demand for labor is wasn't rejected, but the introduction of product innovation appeared to be insignificant for the firm's labor demand.

The hypothesis about positive relationship between energy efficiency and wage rate is rejected. It means that the more energy efficient firms pay lower average wages. The product innovations either negatively influence wage rate, while process innovations have positive effect on the wage rate.

Finally, this work is of very important because it shows what may an average firm expect if it want to implement energy efficient technology and decrease its energy intensity. However, these results considerably depend on the instruments used in the SEM model. All in all, validity of estimates may be improved by using more and better instruments for employment and especially for firm's average wage rate. Moreover, the representative dataset would also significantly improve the quality of this research.

Another thing that could be done to improve this work is to run different regressions for different industries because, for example, in the industries that mostly consume energy resources the effect of energy efficiency improvements should to be strictly positive, whilst completely opposite results would be expected for the industries that produce or extract the energy for selling because of lower aggregated demand for energy sources. As a result this could lead to smaller demand for labor in these industries and lower average wage rate.

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APPENDIX

Table A: Variable description

Variable name	Variable code	BEEPS question
Energy intensity	n2f + n2b	Total annual cost of fuel + total annual cost of electricity in the last fiscal year.
Process innovations	n5a	Total annual expenditures for purchases of equipment in the last fiscal year.
Product innovations	ecao1	Has this establishment introduced new products or services in the last three years?
Employment level	l1	A the end of fiscal year, how many permanent, full-time employees did this establishment employ?
Wage rate	n2a	Total labor cost (including wages, salaries, bonuses, etc) in last fiscal year.
Exporting status	d3c	Percentage of establishment's sales: Direct exports.
Level of foreign competiveness	ecaq64b	Effect on decision on production costs: pressure from foreign competitors.
Level of domestic competiveness	ecaq64a	Effect on decision on production costs: pressure from domestic competitors.
Form of ownership	ecaq5	How this firm established?
Share of workers with higher education	ecaq69	Percent of employees at end of fiscal year with a university degree.
Experience of top-manager	b7	How many years of experience working in this sector does the Top Manager have?
Volume of sales	d2	In the last fiscal year, what were this establishment's total annual sales?
Industry	a4a	Industry sector.
Country	a1	Country code.
Year	Year	Year of survey.