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Innovation, Labour Demand and Wages in Poland. Some Introductory Results Using Micro-macro Data

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Contents

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Abstract[1]

There is a large body of literature on the relationship between innovations and employment at the firm level, with most of the results indicating positive effects. Thus far, this kind of analysis has not been performed for Poland and it seems to be an important and interesting field for research. On the other hand, there is some empirical evidence that developments in the Polish labour market are at least partially driven by the Skill Biased Technical Change (SBTC) process. This paper tries to fill in this gap by looking at three dimensions of the relationship between innovations and employment in Poland: innovations and job creation, innovations and the skill structure of employment innovations, and wage formation. The results of the analysis indicate that there is a weak but positive relationship between the level of innovations and the probability of job creation. However, we have not been able to prove that innovations have any effect on the skill structure of labour demand in Poland. We have however found a positive and statistically significant relationship between the level of innovations and skill-biased wage changes. The results indicate that innovations positively influence the wages of skilled workers while they negatively influence the wages of the unskilled.

[1] Some data transformations and econometric calculations have been performed by Jan Hagemajer from the National Bank of Poland. Nevertheless all responsibility for any deficiencies is mine.

1. Introduction – rationale for the study

There is a large body of literature on the relationship between innovations and employment at the firm level. Although most of the studies found this relationship to be positive (see Vivarelli 2005), its strength or even direction may depend on various factors such as the economic situation of the company or industry, the size of the company, the kind of innovations or the skill level of employees.

For example, Coad and Rao (2007) have found that the biggest positive increase in employment due to innovation can be observed in fast growing firms. On the other hand, innovation decisions that were undertaken by companies reducing their employment were associated with an additional decline in employment. Furthermore, the authors results indicated that innovation in big firms is more likely to lead to labour creation than innovation in small firms.

The relationship between the kind of innovations and their effect on employment is the most widely studied subject in the related literature. In general, it is emphasized that product innovations tend to have much a stronger positive effect on employment than process innovations. Among others, the studies of Entrof and Pohlmeier (1990), Koenig et al. (1995), and Smolny (1998) found that product innovation has a positive influence on employment, which was confirmed by Van Reenen (1997) for the UK, by Garcia et al. (2002) for Spain and by Greenan and Guellec (2000) for France. On the other hand, there are also studies indicating a positive relationship between process innovations and employment, among them Smolny (1998 and 2002) and Greenan and Guellec (2000). The more recent study of Koellinger (2008) indicated that product innovations always result in employment growth, whereas process innovations can also result in employment reductions. In particular, Peters (2004) and Harrison (2005) found that although product innovations always result in employment growth, this is not true for process innovations, which do not influence employment in the services industry and result in employment reduction in the manufacturing industry.

However the number of employees is not the only thing that changes as a result of innovation. Innovation can also influence the structure of employment and wages in companies. For example, Bellman and Schank (2000) obtained very interesting results concerning the relationship between innovations and skills structure and wages of employees. Their results indicated that innovations tend to positively influence the demand for all skill groups of workers with the exception of highly skilled blue-collar workers. Besides this specific group, however, their results also indicated that the higher the skill level, the stronger the positive influence of innovation on employment. They also found that as soon as skilled and unskilled workers were substitutable, the higher wage elasticity of the unskilled could reduce the unemployment for this group.

These results are in line with the literature on Skill-Biased Technical Change which suggests that the changing structure of labour demand in which skilled workers are increasingly preferred results in either high unemployment of the unskilled or increasing wage dispersion (see Krugman (1994), Katz and Autor (1999), Acemoglu (2002) and more recently, Weiss and Garloff (2006)).

Thus far, this kind of analysis has not been performed for Poland and it seems to be an important and interesting field for research. At first it seems plausible to assume that the economic convergence process has to be accompanied by rapid (in comparison to other developed countries) technological change. The evidence for this technological change and its relatively quick pace can be found in Polish data on the technological intake of polish export. According to the OECD data cited in Jakubiak (2006) only in 1992-2003 did the value of Polish high-tech exports increase from zero to 4 billion USD (about 10% of total exports), and for medium-tech products the increase was from 3 billion (about 15% of total exports) to 18 billion (about 45% of total exports) during the same period.

At the same time, the Polish labour market experienced a rapid evolution of employment skills structure accompanied by increasing wage dispersion. Existing studies suggest that this process is strongly related to the increasing demand for a high skilled (educated) workforce, see Socha&Newell (2007). Other estimates, such as the decomposition of the Theil inequality index, suggest that the share of education in total wage inequality in Poland increased in 1996-2004 from 12% to 22%, see Marcinkowska et al (2008). The results of econometric estimates from the same study also point to the strongly increasing returns to education in recent years. This resulted in the dynamic increase of total wage inequality in the same period – the GINI coefficient increased from 0.28 to 0.33.

Poland's generally low levels of employment are one of the major economic challenges for its policy-makers. Additionally the employment rates in Poland are strongly related to skills; the differences in employment rates among groups with different skill levels has substantially increased within last 10 years. The employment rate of those with tertiary education in Poland in 1997 was 2.5 times higher than the employment rate of those with maximum lower secondary education. This factor increased to 3.3 until 2007. In the EU15 countries, it is stable and is around 1.6 (own calculations based on EUROSTAT data).

The empirical evidence above suggests that developments in the Polish labour market can at least partially be driven by the Skill Biased Technical Change (SBTC) process. It seems also that these processes in Poland (and also in other economies in Central and Eastern Europe) can be much stronger than in other developed (EU or OECD) countries.

If this is true, the relationship between innovations and the labour market behaviour of Polish companies should also be easily detectable at the micro level. It should result in an increase of relative demand for skilled workers at the expense of the unskilled. This structural change in demand should either manifest itself in changes in the employment structure or in changes in the relative wages of the skilled and unskilled. Both processes can also take place. In this paper we present the first results of analysis trying to test this hypothesis.

This paper tries to answer these three research questions: one is more general on the relationship between innovation and employment and the other two directly result from the theoretical expectation of the SBTC theory.

At first we analyse the relationship between innovations and job creation, and try to find out whether innovations have any positive or negative effect on job creation. Next, we try to differentiate among the various groups defined by their respective education levels and look at the job creation effect of innovations depending on the skill level. The third part of the analysis is devoted to the relationship between innovations and wages. We look at the effect of innovations on wages of the skilled and unskilled workers.

The rest of the paper is organised as follows: in the first part we present the data-sets used and the way they have been merged, and give the definitions of all variables used in the econometric analysis. The third part presents the results of the analyses. The last section summarises and concludes.

2. Data used

In order to analyse the micro-level relationship between any activities at the enterprise level (including innovations) and labour market responses such as size of employment, employment structure, turnover or wages one should perform the analysis on the longitudinal (or at least a rich cross-section) matched employer-employee data set. Such a data-set enables one to investigate the direct relationship between the developments at the company level and the behaviour and situation of individual employees, controlling for individual characteristics of employees such as age, gender or (most interesting from our point of view) education (skill) level. Unfortunately such a data set does not exist in Poland. We have attempted to overcome this problem by combining two separate sources of data.

In order to have information on the behaviour of companies we have used data from Polish companies for the years 2004-2006. This information is collected by the Polish Central Statistical Office (CSO) using the so-called F01 questionnaire, hence further in the text we call this dataset “F01”. To have information on individuals, we used the micro-data from the Polish Labour Force Survey (PLFS) from the same period.

The F01 is a panel of more than 15,000 Polish enterprises employing more than 50 persons. It includes detailed annual information on the financial situations of enterprises, such as sales, costs, profits etc. It also includes other information such as number of employees and various cost and investment spending grouped by accounting but also economic categories. Most importantly for us, it also contains information on selected kinds of innovation spending (see Table 1 for details).

Access to F01 data is unfortunately tightly controlled by the CSO. At this stage, thanks to the co-operation of the National Bank of Poland, we were able to have limited access to semi-aggregated information where part of the calculations had to be performed by NBP staff. Therefore the information on companies enters the analysis at the level of crosses of the industries (1-digit NACE) and NUTS2 regions. It should theoretically result in 288 observations (18 industries in 16 regions). In practice, due to limitations related to statistical anonymity (not enough individual companies in a given industry and region) and simply a lack of any observations from some industries there were only 112 observations (7 industries in 16 regions) per year.

As there is no “innovations” spending category in the F01 data-set, we had to construct it using the information available. Innovations expenditures were defined as the total amount spent on: patents, licences and new software (see Table 1). Therefore we did not take into account factors such as own R&D activities or innovative shifts in organisational structures etc. More importantly it does not allow for differentiating among the product and process innovations which can seriously influence both the direction and strength of the results obtained. One has to have all these deficiencies in mind when interpreting our results.

One can however reasonably assume that expenditures on patents, licenses and new software are strongly correlated with more widely defined innovation activities and some simple correlations seem to prove this. The correlation coefficient between the innovation proxy used in this paper and the EUROSTAT regional data on R&D in the business sector is 0.56 for 2004 and 0.66 for 2005.

The PLFS data include all the necessary information on individuals that can influence their labour market performance such as: age, education, gender, working tenure, region and kind of locality of their residence, industry and size of the company they work in.

Hence the final data-set used in the analysis was the product of a merge of semi-aggregate information on companies (or industries in regions) for the years 2004-2006 with the micro-PLFS data for 2006. This combined data-set has been used for the econometric analysis. The detailed definitions of all variables used in all parts of econometric analysis are presented in Table 1. As one can see, except for the innovation variable and some regional control variables, all the information used in the econometric analyses came from PLFS data, and hence entered the analysis at the micro level.

Table 1. Variables used in analysis, original source data-sets, aggregation level and definitions

Variable Name	Definition	Source	Aggregation level	Comments
NEW	New employer = 1 if employed in given company for less then 1 year, 0-otherwise	PLFS	Individual	Dependent Variable in "job creation" equations
INNOV	The share of innovations expenditures in total sales	F01	NACE1 in Voivodships	Innovations expenditures are: patents, licences, new software.
AGE	Age of an employee	PLFS	Individuals	
GENDER	Gender of an employee	PLFS	Individuals	
EDU	Education level of an employee	PLFS	Individuals	
OWN	Ownership type of the company – public or private	PLFS	Individuals	
IND	Industry (NACE 1 digit)	PLFS	Individuals	
UN	Regional Unemployment Rate	EUROSTAT	Voivodships	
UNDIFF	Regional unemployment rate change 2004-2006	EUROSTAT	Voivodships	
ROTATION	Estimated individual probability of losing a job	Estimated using PLFS data	Individuals	Proxy (control) for job rotation (job destruction). Prediction of logistic model with: EDU, PROF, LOCAL, IND, VOI, GENDER used as explanatory variables and LOSER used as dependent variable.
LOSER	Job loser = 1 if a person does not have a job and lost within last 12 months, =0 otherwise	PLFS	Individuals	Used in model generating the ROTATION variable as dependent variable.
OCCUP	Occupation of an employee (1 digit ISCO)	PLFS	Individuals	
LOCAL	Size of locality of residence (countryside, small town, large city)	PLFS	Individuals	
VOI	Voivodship of residence	PLFS	Individuals	
logwage	Natural logarithm of net wage of full time employees	PLFS	Individuals	Used in wage model as dependent variable

Source: The author

3. Results of econometric estimations

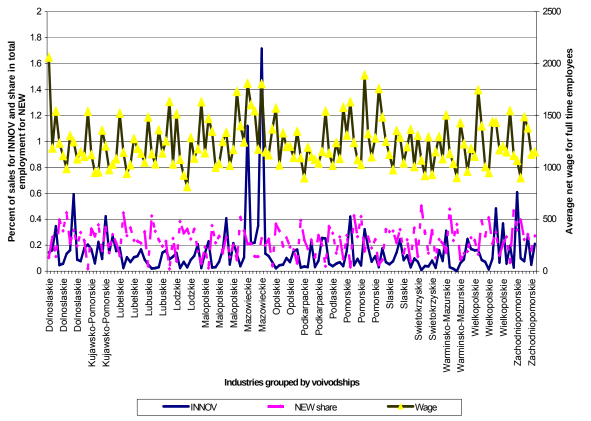
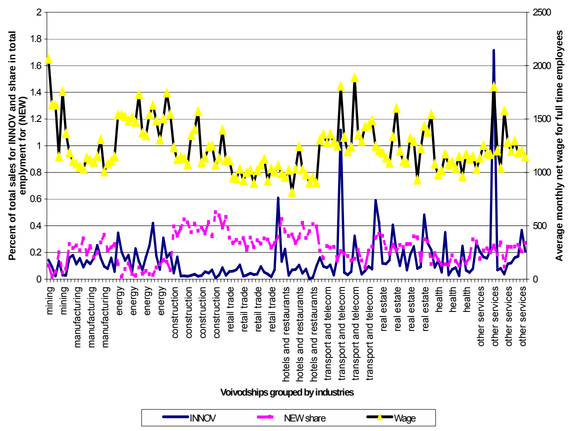
3.1 Distributional features of innovation, job creation and wage variables

Before presenting the results of econometric estimations one should look carefully at some distributional features of innovation, job creation and wage variables at the semi-aggregate level since they seem to seriously influence the results obtained.

At first the innovation expenditures are strongly concentrated in certain voivodships and industries. As much as 42.6% of total innovation expenditures are located in the Mazowieckie (capital) voivodship. This is partially a result of the regional distribution of total sales with enterprises from the Mazowieckie region reaching 25% of total sales in our sample. On the other hand the average share of innovation expenditures in total sales in the Mazowieckie region is also higher than in other parts of the country reaching 0.58% whereas the average for all other regions is only 0.13%

Innovation expenditures are also concentrated in selected industries. As much as 34% of total innovation expenditures are in the transport and communication sectors and the other 32% in manufacturing. Part of this concentration can be also explained by the relative size of the industries. Manufacturing was as much as 41% of total sales in the sample, hence in this case the actual share of innovations in total sales is even smaller than the average. On the other hand, however the share of transport and communication in total sales is only 9%, and here these expenditures are much higher than the average.

Figure 1. The average share of innovations in total sales (INNOV variable) in years 2004-2006, the average gross job creation (NEW variable=1) and the average wage across the semi-aggregate observations (cross of industries and voivodhips)

Panel A (observations grouped by voivodships)	Panel B (observations grouped by industries)
	

Source: Author's recalculations based on calculations performed by NBP on F01 data set.

This all results in a very unequal distribution of the INNOV variable (see Table 1 for definition). In some observations (crosses of voivodships and industries) the value of the INNOV variable is much higher than for others (see Figure 1). It is particularly true for two observations (industries) in the Mazowieckie voivodship, namely, transport and communications and other services. In these two crosses, the average share of innovation expenditures in total sales in the years of 2004-2006 exceeded 1%, whereas the average for all other crosses is 0.13%. As a result, we decided to run all of the estimations below on two samples: the full one containing observations from these two crosses and a sub-sample where these two crosses were excluded. Additionally we have also run estimations on the full sample with all the models' specifications augmented with an additional dummy variable. As we will see later it seriously influences the results of part of our estimations.

The other distributional features of INNOV and of the other two variables are the most important from our point of view. WAGE and NEW are much less problematic, although one can also observe some interesting characteristics. It seems that the share of innovation expenditures in total sales is significantly below average for all voivodships in the construction and retail trade industries. In the same industries, the average share of new workers in employment seems to be above average. On the other hand, the number of new employees is lower than average in the energy sector. It seems also that wages tend to be lower in retail trade and in the hotel and restaurant industries for all voivodships.

3.2 Innovations and job creation

In order to analyse the relationship between innovations and job creation we have estimated the logistic model for probability of being a new employer in the company of the following form:

(1)

$$logit(P_{new}) = \beta_0 + \beta_1 INNOV + \beta_2 AGE + \beta_3 AGE^2 + \beta_4 GENDER + \beta_5 EDU + \beta_6 IND + \beta_7 OWN + \beta_8 UNDIFF + \beta_9 UN + \beta_{10} ROTATION$$

The model has been estimated based on individual micro-level data from PLFS for 2006 merged with semi-aggregated data from F01 for the years 2004-2006 and regional information for EUROSTAT for the same period. It has been estimated only for employees of companies with more than 20 employees to match the estimation sample with the data from F01 covering only companies employing more than 50 workers.

It is a standard reduced form model used for estimating individual employment probability augmented by company related variables (IND and OWN), variables characterising the static (UN) and dynamic (UNEDIFF) situation on the regional labour markets and the two additional explanatory variables. The INNOV variable (see Table 1 for detailed definition) has been calculated as the average share of innovation expenditures in total sales for the years 2004-2006.

The dependant variable in the model (NEW) assumes the value of “1” if an employee has been working at his or her current workplace for less than 12 months (see also Table 1). Hence what we are estimating in fact is how various company, regional and personal characteristics influence the probability that a given person is a new employee (and not an “old” employee). What we are mainly interested in, however, is the explanatory features of the INNOV variable, with all of the other variables serving only as controls. We want to know whether the fact that given companies (in fact due to data limitations companies of a given branch in a given voivodship) invest more in innovations than the others increases the probability that they will have more new employees.

Due to the specific definition of the employment probability variable used in this estimation we have also introduced one more control variable to the model. The ROTATION variable is the estimated individual probability of losing one’s job (see Table 1 for detailed definition). The need to include this variable into the model results from the empirical observation that in general, the probability of being a new employee is strongly and positively correlated with the probability of losing one’s job. In other words, many of the new workers are those who had lost (quit) their previous jobs and hence were forced (wanted) to look for a new one. These are mainly younger people with lower education levels working in specific industries (mainly services) and performing simple jobs as they tend to change jobs much more frequently than others. The inclusion of this variable is an attempt to control for this (job rotation) phenomenon.

Controlling for job rotation allows us to assume that by estimating the probability of being a new employee, we actually measure the influence of independent variables on job creation. In particular it enables us to assume that we are able to measure the influence of innovations spending on job creation.

Table 2. Main results of estimations for probability of job creation – various specifications, coefficients presented as log odds ratios

	Full data set			Data set with "outliers" excluded			Dummy for Outliers
	1	2	3	4	5	6	7
OWN (private=1)	2.12436	1.93574	2.18485	2.08773	1.91276	2.16875	2.12437
P-values	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
EDU1-tertiary	0.99264	1.1554	0.77315	1.00607	1.17251	0.78309	0.99257
P-values	-0.911	(0.019)*	(0.000)**	-0.928	(0.011)*	(0.000)**	-0.91
EDU2-secondary vocational	0.92658	0.97454	0.78644	0.91791	0.96503	0.77728	0.92655
P-values	-0.117	-0.583	(0.000)**	-0.081	-0.453	(0.000)**	-0.117
EDU3 – secondary general	0.81392	0.83628	0.86855	0.81364	0.83584	0.86944	0.8139
P-values	(0.003)**	(0.009)**	(0.035)*	(0.003)**	(0.009)**	(0.038)*	(0.003)**
EDU5 – below vocational	1.31661	1.31504	1.71746	1.30506	1.3052	1.70586	1.31657
P-values	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
GENDER - female	0.83018	0.79017	1.02705	0.82563	0.78712	1.02497	0.8302
P-values	(0.000)**	(0.000)**	-0.466	(0.000)**	(0.000)**	-0.505	(0.000)**
AGE	0.81653	0.82937	0.71961	0.81867	0.83098	0.71995	0.81652
P-values	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
AGE^2	1.00166	1.00151	1.00325	1.00163	1.00149	1.00325	1.00166
P-values	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
ROTATION	1.05803	1.06595		1.05852	1.06609		1.05802
P-values	(0.000)**	(0.000)**		(0.000)**	(0.000)**		(0.000)**
UNEMPDIFF	0.9688	0.977	0.97834	0.97247	0.97588	0.97711	0.96875
P-values	-0.14	-0.088	-0.107	-0.196	-0.074	-0.089	-0.14
UNEMP	1.00196	0.99985	1.03796	1.00623	1.00015	1.0387	1.00222
P-values	-0.932	-0.991	(0.003)**	-0.794	-0.99	(0.002)**	-0.925
INNOV	1.51678	1.50385	1.40289	1.26448	1.22563	1.03343	1.50526
P-values	(0.001)**	(0.000)**	(0.000)**	-0.333	-0.273	-0.86	-0.062
IND control	included			included			included
VON control	included			included			included
Observations	24459	24459	24463	23999	23999	24001	24459
Pseudo R^2	0.173	0.161	0.154	0.172	0.16	0.153	0.173

Source: Author's estimations based on PLFS data and aggregated data from F01
Base category for categorical variables: male with vocational education working in private sector.

The results of the estimations (Table 2) strongly depend on whether or not one includes the observations from transport, telecommunication and other services from the Mazowieckie voivodship for which the share of innovation expenditures in total sales (the value of the INNOV variable) is extraordinarily high.

Results for the full data set (columns 1, 2, and 3 of Table 2) indicate a positive relationship between innovation expenditures and job creation. The estimated coefficient (all coefficients in Table 1 are expressed as log odds ratios) is larger than 1 and statistically significant (see P-values) independent of the details of model specification.

Three model specifications are presented in Table 2. Column 1 presents the results of full model specification with regional (VON) and industry (IND) control variables and with the ROTATION variable included. The results in column 2 have been obtained by estimating a model without regional and industrial control variables. The ROTATION variable was additionally excluded from the model specification in column 3.

In accordance with earlier expectations related to the important role played by the ROTATION variable in the model, the coefficients presented in column 3 are qualitatively different from those in columns 1 and 2. When this variable is included, the estimated coefficients for tertiary or secondary vocational education are either statistically insignificant (column 1) or positive (column 2). This indicates that the probability of job creation for those with education levels above secondary is, *ceteris paribus,* either the same or higher than for those with vocational education. On the other hand, when the ROTATION variable is not included in the model, the estimated effect of tertiary and secondary vocational education on the probability of being a new employee in a company is negative. This clearly results from a much higher job rotation among those with lower education levels. One can also observe the important role played by this variable when analysing the differences in estimated coefficients on the regional unemployment rate (UNEMP). When it is not used, the unemployment rate seems to positively influence job creation.

Adding the ROTATION variable to the specification also influences the estimated effect of innovations on job creation. The coefficients are higher when the ROTATION variable is used. On the other hand they stay positive and statistically significant when the ROTATION variable is excluded from the model specification. This suggests that innovations can also increase job rotation as such. Those companies that spend more on innovations tend to replace employees more frequently that those that spend less.

The results obtained become very different if one excludes the observations with extremely high shares of innovation expenditures in total sales ie. those from transport and communication and other services industries in the Mazowieckie voivodship. In this case the estimated coefficients on INNOV are not statistically significant, indicating there is no relationship between innovations and job creation (see columns 4, 5, and 6 of Table 2).

If we treated high innovations expenditures recorded for these observations as simple unexplainable outliers, or just as the results of some measurement errors, we would have to treat these results as more reliable. On the other hand, it seems that this data reflect a real distribution of innovation expenditures in Poland, where technological change and related innovations are seriously concentrated in development clusters located around the largest cities. This would mean that by simply excluding these observations from the sample, we limit and alter (i.e. put the bias on) the actual information used in the estimation. Therefore we have also estimated a model based on a full sample with an additional dummy variable added for the related observations, (see column 7 in Table 2). The results of this estimation are rather inconclusive, although they also seem to suggest at least some weak relationship between innovations and employment in Poland. The coefficient on the INNOV, although positive, is very weakly insignificant (at the standard “lower bound” confidence level of 95%), with the p-value equal to 0.06.

3.3 Innovations and skills structure

If innovations lead to skill-bias in labour demand, the positive relationship between innovations and job creation should be stronger for those with higher education levels. In order to test whether this is true, we have estimated a model (2) with a multiplicative variable testing the interaction effects of the education and innovation variables:

(2)

$$logit(P_{new}) = \beta_0 + \beta_1 INNOV + \beta_2 AGE + \beta_3 AGE^2 + \beta_4 GENDER + \beta_5 EDU + \beta_6 IND + \beta_7 OWN + \beta_8 UNDIFF + \beta_9 UN + \beta_{10} ROTATION + \beta_{11} EDU{*}INNOV,$$

where EDU*INNOV is an interaction variable for EDU being the indicator categorical variable for education and INNOV being the continuous variable for share of innovation expenditures in total sales in given cross of voivodship and industry.

Table 3. The results of job creation estimations with interaction variables for education levels and innovation expenditures and separate estimation for various education levels

	1	2	3	4	5	6	7
	Interaction variables		**Separate estimations for each education level**				
	Without dummy	With dummy	tertiary	secondary vocational	secondary general	vocational	Primary
OWN (private=1) P-values	2.1241 (0.000)**	2.12414 (0.000)**	1.90128 (0.000)**	1.73184 (0.000)**	1.76024 (0.005)**	2.89106 (0.000)**	1.75291 (0.005)**
EDU_tertiary P-values	0.98986 -0.896	0.99006 -0.898					
EDU_secondary vocational P-values	0.85696 (0.013)*	0.85707 (0.013)*					
EDU_secondary general P-values	0.75641 (0.001)**	0.75641 (0.001)**					
EDU_basic P-values	1.1612 -0.122	1.16061 -0.123					
INNOV P-values	1.12625 -0.61	1.09448 -0.755	1.32324 -0.251	1.87372 (0.006)**	2.52275 (0.028)*	0.94343 -0.833	1.80341 -0.268
EDU1*INNOV P-values	1.10776 -0.702	1.1046 -0.71					
EDU2*INNOV P-values	1.70434 (0.044)*	1.70115 (0.044)*					
EDU3*INNOV P-values	1.63715 -0.16	1.6357 -0.161					
EDU5*INNOV P-values	2.46328 (0.047)*	2.47056 (0.047)*					
GENDER P-values	0.83092 (0.000)**	0.83099 (0.000)**	0.90332 -0.347	0.642 (0.000)**	0.99061 -0.952	0.98092 -0.84	0.62975 (0.016)*
AGE P-values	0.81587 (0.000)**	0.81585 (0.000)**	0.63474 (0.000)**	0.80759 (0.000)**	0.73548 (0.000)**	0.86965 (0.000)**	1.05628 -0.375
AGE^2 P-values	1.00167 (0.000)**	1.00167 (0.000)**	1.00444 (0.000)**	1.00172 (0.000)**	1.00273 (0.000)**	1.00105 (0.011)*	0.9986 -0.065
ROTATION P-values	1.05799 (0.000)**	1.05797 (0.000)**	0.98686 -0.484	1.0875 (0.000)**	1.04803 (0.007)**	1.05729 (0.000)**	1.07558 (0.000)*
UNEMPDIFF P-values	0.96905 -0.143	0.96886 -0.141	0.96183 -0.429	0.97286 -0.504	0.97145 -0.713	0.99607 -0.915	1.01543 -0.836
UNEMP P-values	1.00199 -0.931	1.003 -0.899	1.06985 -0.324	0.95396 -0.269	1.06474 -0.455	0.96962 -0.414	1.03093 -0.701
DUM_outiers P-values		1.05325 -0.868					
VOI control	included	included	included	included	included	included	included
IND control	included	included	included	included	included	included	included
Pseudo R	0.173	0.173	0.173	0.21	0.28	0.13	0.162
Observations	24459	24459	4120	8073	1953	8527	1761

Source: Author's estimations based on PLFS data and aggregated data from F01
Base category for categorical variables : male with vocational education (4) working in private sector.

The results of these estimations are presented in Table 3 in columns 1 and 2 and they do not seem to be encouraging independent of the inclusion (column 1) or not (column 2) of the dummy variable for outliers (defined as in part 3.1). For both specifications, job creation for the base education category (vocational, see main effect) is not related to innovation expenditures. Tertiary education of employees (see interaction effect for EDU-tertiary and INNOV) does not seem to make this relationship any stronger either. On the other hand, it seems that innovations tend to positively influence job creation among workers with secondary vocational education. The effect, however, is even stronger for those who have not even finished vocational schools (ie. the lowest education category). Although the former seems to be in accordance with theoretical expectations, the latter is definitely not. It would mean that innovations most strongly affect the creation of jobs for those people with the lowest educational degree.

The results presented in columns 3-7 of Table 3 seem to be slightly more encouraging. Here the estimations have been performed for each education level separately. The results obtained do not indicate any positive effect of innovation expenditures on job creation for those with tertiary education (column 3, Table 3). The results do indicate a positive effect on job creation for those with secondary vocational (column 4) and secondary general education (column 5). Such a relationship was not detected for those with vocational education (column 6) and below (column 7). The message here is mixed, although these results do not support our initial hypothesis of a stronger relationship between innovation and job creation for those with higher education levels, they are not against it either.

Unfortunately, adding the outlier dummy variable to the estimation presented in columns 3-7 of Table 3 results in insignificant coefficients on the INNOV variable for all educational groups. It proves the very strong role of specific results from the Mazowieckie voivodship for results of all our estimations (these results are not presented in Table 3).

3.4 Innovations and wages

While skill biased changes in labour demand are the expected effect of innovations, they do not have to alter the employment structure. Instead they may manifest themselves in an increase in the relative wages of skilled workers as compared to the unskilled. An attempt to test for such a relationship in Poland was the last objective of our analysis.

In order to analyse the relationship between innovations and wage developments, we have estimated the simple OLS augmented Mincerian logwage regression with interaction variables for education levels and innovation expenditures of the following form:

(3)

$$logwage = \beta_0 + \beta_1 EDU + \beta_2 AGE + \beta_3 AGE^2 + \beta_4 GENDER + \beta_6 IND + \beta_7 OWN + \beta_8 OCCUP + \beta_9 LOCAL + \beta_{10} VOI + + \beta_{11} INNOV + \beta_{12} EDU*INNOV$$

where all variable definitions can be found in Table 1. All the estimations have been performed only for full time employees as the wage data in the PLFS refer to monthly payments.

Table 4 presents the estimations results. The results in columns 1-3 where obtained by OLS estimations and the results in columns 4-6 by OLS estimations with robust standard errors (Huber/White/sandwich estimators) due to the detected heteroscedasticity of the standard OLS models' residuals. A change in the estimation method does not substantially alter the significance of results (and by definition does not alter the size of the estimated coefficients).

Similarly, as in case of job creation estimations, wage equations have also been estimated using three different specifications and/or samples. Columns 1 and 4 present the results of full sample estimations of the model specified exactly as in the specification (3), columns 2 and 5 present the results of the same model specification but estimated on the sample with outliers excluded (where outlier observations are the same as for job creation models), columns 3 and 6 present the results of estimations performed for a full sample with an additional dummy variable for outliers.

The effect of standard Mincerian variables are in accordance with the general theoretical expectations for all specifications. Wages are lower for females than for males (by slightly more than 20%). Wages are an increasing and concave function of age and monotonically increase with education level. The coefficients on other explanatory and control variables (not included in Table 4) are also as expected: wages are higher (*ceteris paribus*) in the private sector by about 6%. They also increase with the size of locality with the highest wages estimated for the large cities.

The main effect of innovations on wages is negative and significant for two out of three specifications and only marginally insignificant for the third one. Adopting the estimation with robust standard errors improves the statistical significance of the estimated coefficients, (lowering) the p-value. This means that, for those with vocational education, the effect of innovation on wages seems to be negative. An increase in the share of innovation expenditures in total sales by 1 percentage point reduces the wages of those with vocational education by 9% to 18%. Obviously this effect is not large when taking into account that the average share of innovation expenditure in total sales in our sample is 0.13%. Doubling the average figure would decrease the wages of those with vocational education by about 1 - 1.5%.

Table 4. Selected results of estimations of logwage models with multiplicative interaction variables for education levels and innovations (PLFS data for 2006)

	Standard OLS			OLS with robust standard errors		
	1	**2**	**3**	**4**	**5**	**6**
GENDER	-0.22739 (0.000)**	-0.22756 (0.000)**	-0.22736 (0.000)**	-0.22739 (0.000)**	-0.22756 (0.000)**	-0.22736 (0.000)**
AGE	0.03043 (0.000)**	0.02983 (0.000)**	0.03042 (0.000)**	0.03043 (0.000)**	0.02983 (0.000)**	0.03042 (0.000)**
AGE^2	-0.0003 (0.000)**	-0.0003 (0.000)**	-0.0003 (0.000)**	-0.0003 (0.000)**	-0.0003 (0.000)**	-0.0003 (0.000)**
EDU_tertiary	0.27353 (0.000)**	0.24866 (0.000)**	0.27341 (0.000)**	0.27353 (0.000)**	0.24866 (0.000)**	0.27341 (0.000)**
EDU2_secondary vocational	0.08815 (0.000)**	0.07999 (0.000)**	0.088 (0.000)**	0.08815 (0.000)**	0.07999 (0.000)**	0.088 (0.000)**
EDU3_secondary general	0.08767 (0.000)**	0.09022 (0.000)**	0.08742 (0.000)**	0.08767 (0.000)**	0.09022 (0.000)**	0.08742 (0.000)**
EDU_primary	-0.04283 (0.003)**	-0.02723 -0.121	-0.04373 (0.002)**	-0.04283 (0.001)**	-0.02723 -0.103	-0.04373 (0.001)**
INNOV	-0.05521 -0.06	-0.18363 (0.001)**	-0.09252 (0.024)*	-0.05521 -0.052	-0.18363 (0.000)**	-0.09252 (0.025)*
EDU1*INNOV	0.16033 (0.000)**	0.40838 (0.000)**	0.15936 (0.000)**	0.16033 (0.001)**	0.40838 (0.000)**	0.15936 (0.001)**
EDU2*INNOV	0.01081 -0.76	0.0844 -0.225	0.01077 -0.761	0.01081 -0.787	0.0844 -0.2	0.01077 -0.787
EDU3*INNOV	0.09268 -0.088	0.08003 -0.477	0.09301 -0.087	0.09268 -0.24	0.08003 -0.572	0.09301 -0.241
EDU5*INNOV	-0.09542 -0.17	-0.23272 (0.037)*	-0.08937 -0.2	-0.09542 -0.123	-0.23272 (0.015)*	-0.08937 -0.143
DUMMY for outliers			0.05968 -0.192			0.05968 -0.255
OCCUP, VOI, IND, OWN, LOCAL	included	included	included	included	included	included
Constant	6.72854	6.75379	6.73596	6.72854	6.75379	6.73596
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
Observations	16143	15829	16143	16143	15829	16143
R-squared	0.437	0.431	0.437	0.437	0.431	0.437

Source: Author's estimations based on PLFS data and aggregated data from F01
Base category for categorical variables : male with vocational education (4) working in private sector.

The estimated influence does not change for those with secondary general and secondary vocational education levels, as the interaction coefficients for those groups are statistically insignificant (ie. equal to zero).

For those who do not even have vocational education, innovations tend to decrease wages even more than for other groups, although this effect is statistically significant only if most innovative regions and industries are excluded from the estimation sample. Otherwise the effect does not differ from the main one (ie. still being negative).

For those with tertiary education levels, the total effect[2] of innovations on expected wages is positive. In this case, for all specifications the estimated coefficients are positive, significant and larger than the negative main effect. Doubling the average share of innovation expenditures in total sales would increase the wages of this group by 0.5% to 2%, depending on the estimation sample and model specifications.

This means that in regions and industries which have invested more in innovations, the expected wages of those with tertiary education are, *ceteris paribus,* higher than in those regions and industries where such investments were lower. On the other hand, the wages of all the other education groups seem to be lower in innovating companies.

4. Concluding remarks

In this paper we have presented the results of introductory micro-macro level analysis of the relationship between the innovation expenditures and labour market developments in Poland. As neither the matched employer-employee data set nor even the appropriate micro-data from companies are available for Poland, we used the PLFS (Polish Labour Force Survey) data where the companies have been proxied (identified) as the crosses of on-digit NACE industries and voivodships – NUTS-2 Polish regions. The information on innovation expenditures at this semi-aggregate level has been obtained from F01 (the micro-level data-set from polish companies employing more than 50 employees is not available at the disaggregated micro level).

Using the merged data-set, we analysed the relationship between innovation expenditures of companies for the years 2004-2006 and the job-creation and wage formation in the year 2006. We have tried to answer three main research questions:

- Do innovations affect job creation in general?

[2] In order to calculate the effect of innovation on wages of any groups we have to add the main effects coefficient and interaction effect coefficient

- Does the effect of innovations on job creation differ among the skilled and the unskilled?
- Do innovations influence (increase?) the relative wages of the skilled versus the unskilled?

The introductory results of the first part show a positive relationship between innovation activities and job creation in general. The estimated coefficient on innovations in the logit model for job creation probability has been positive and statistically significant irrespective of the detailed model specification. The significance of the result however is not robust to the estimation sample changes resulting from the exclusion of outlier observations. In this case the estimated coefficient is not statistically significant. If the outliers are controlled for by adding the dummy variable to the model, the estimated coefficient is “very close to being significant” with the p-value equal to 0.06. We can conclude that this part of our analysis indicated for a weak but positive relationship between innovation expenditures and job creation in Poland.

The second part of the analysis does not lead to a conclusive outcome. The result obtained when the model with interaction variables on education levels and innovations is estimated shows that innovations positively influence job creation only for those with primary education (the lowest level) and with secondary vocational education (the second highest). Both coefficients are only marginally significant and additionally the value of the estimated coefficient is higher for the former group which is against any theoretical expectations.

Slightly less discouraging results have been obtained when the job creation model was estimated for each and every education group separately. The positive and statistically significant coefficients on innovations for those with secondary vocational and secondary general education are not against the theory, although once again the value of the coefficient is unexpectedly larger for the latter group. For the other groups (unfortunately including those with tertiary education) innovations do not seem to positively influence job creation.

The results of the second part of the analyses are mixed and one is unable to give them any meaningful interpretation. They do not show whether or not innovation has any effect on the skills structure of labour demand in Poland.

The results of the last part of the analysis however are much more conclusive. Independently of the model specification and the sample used, innovation expenditures are positively correlated with the wages of employees with at least tertiary education. On the other hand, the wages of those with vocational education, and even more of those with primary education are negatively correlated with innovation expenditures. It is very important that the qualitative meaning (sign and statistical significance) of the results obtained does not change with the model specification and with the specific estimation technique applied. This means we can treat them as robust and systematic. Based on these results, we can conclude that the relative wages of skilled workers in Poland are higher in those industries and regions where innovation expenditures constitute a higher share of total sales. This is a meaningful conclusion proving the relevance of the SBTC theory for the wage formation process in Poland.

On the other hand our results indicate also that innovations negatively influence the wages of those with secondary general and secondary vocational education. The estimated relationship for these groups does not significantly differ from results obtained for those with vocational education (interaction coefficients are not statistically significant). It would suggest that innovations in Poland favour only those with tertiary education. It can be result from the systematic undersupply of employees with tertiary education in Poland, but it can also be the consequence of deficiencies of our analysis.

Allowing for a more relaxed interpretation of the combined results of our analyses, one can conclude that innovations in Poland neither limit job creation for unskilled groups nor do they stimulate job creation for the skilled. On the other hand, innovations seem to strongly increase the relative wages of the skilled versus unskilled groups. This means that the entire effect of the changing structure of labour demand in Poland is accommodated by wage adjustment. This would explain the high flexibility of relative wages in Poland. This interpretation of the results obtained would be in line with Bellmen&Shank (2000) in respect to the substitutability of wage and employment flexibility in reaction to innovations.

On the other hand, one has to remember that despite the use of the special control variable, we were most probably not able to fully take into account the strong job rotation component of the job creation variable used in our models as the dependent variable. This means that our results can in fact indicate for the positive relationship between innovations and job rotation for some skill groups. Such an interpretation would explain the strong and positive relationship between innovations and employment probability for the groups with the lowest educational attainment. It would mean that innovations, and hence technical changes, do not only reduce the relative wages of the unskilled but also increase the job rotation among these groups. It is also possible that the depressed wages induce high job rotation as unskilled workers are pushed to look for jobs in other industries where they can expect higher wages.

The inconclusiveness of our results related to innovations and job creation can also result from the specific measure of innovations we used and from the high aggregation level of innovation information we had at our disposal. Due to the measure used, we have not been able to differentiate between process and product innovations and as the earlier literature on the subject suggests it can play a decisive role for the results obtained. High aggregation levels obviously had to result in further blurring the detected relationship.

Obviously it is impossible to test the hypotheses and solve the above problems by means of the analysis applied in this paper. It requires further research based on more appropriate data-sets and also possibly applying more sophisticated econometric techniques. This work will obviously be continued. It seems however that in this paper, applying simple analysis to the inferior data-set, we have been able to show that innovations influence the shape of labour demand in Poland and that this influence is compatible with the expectations of SBTC theory.

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