Innovations in the industry of Poland

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Abstract: - The most important objective of this study is to determine the regression dependence of the sold production of new and significantly improved goods on the real and human capital expenditure streams in Polish industry in the years 2005-2007, 2008-2010, and 2011-2013. The impact of the expenditure on real (0.646 – 2005-2007, 0.517 – 2008-2010 and 0.868 – 2011-2013) and human capital (0.297 – 2005-2007, 0.709 – 2008-2010 and 0.190 – 2011-2013) on shaping the relative level of sold production of new and significantly improved goods in Polish industry is suggested. The studies demonstrated that the negative structuration of human capital determines its poor utilization in Polish industry; while the passive transfer of technologies, including new machinery and tools, as well as means of transport, dominated in shaping the relative level of innovative production in Polish industry.

Key - Words: - innovation of expenditure and production, regression dependence.

1. Introduction

The issue of industry innovativeness is important for the growth of the Polish economy. Innovativeness also becomes a pressure from the environment which forces enterprises to utilize innovations in building the level of competition in the market, but also preconditions the further effective growth of enterprises. Poland is on one of the last places in the rankings of expenditure on research and development activities, transfer of technologies, or implementation of process and product innovations (Szabo et al., 2013; Slach et al., 2013). In 2010 Poland was in the group of countries catching up with the level of innovations; currently, it is only a modest innovator (Innovation Union Scoreboard, 2013). An average enterprise in the EU spends 10-fold more on research and development than a Polish enterprise.

The objective of the study is to determine the regression dependence of the sold innovative production on streams of expenditure on real and human capital in Polish industry in the years 2005-2007, 2008-2010 and 2011-2013. Its further objective is to indicate the impact of expenditure on real and human capital on shaping the relative level of the sold innovative production in Polish industry.

Hypothesis: The unfavourable proportions of human capital step out to factual capital in implementation of innovation in Polish industry.

2. Selected source literature

Here The source literature suggests that the direct measures of the potential of innovations are expenditure on research and development which do not in their entirety constitute the implementation of innovations in an enterprise. At the same time, measuring innovative production is not easy (Zemplinerová & Hromádková, 2012). Moreover, expenditure on research and development increase productivity by decreasing production costs. Therefore, they are a substitute for measuring innovative activity (Griliches, 1986). Another important factor is the relationship between assets and streams (expenditure) on the structure of human capital. Innovative resources, although they represent streams (expenditure) of real and human capital, do not include even the most fundamental streams of expenditure of these capitals.

Large enterprises have resources sufficient to implement innovations which lead to production growth. In this way, large enterprises are the main source of building the potential of innovations (Schumpeter, 1942) (the Schumpeterian theory). On the other hand, however, competitive industry is more motivated to invest in research and development than a large enterprise (a monopolist) (Arrow, 1962). In turn, intensive increase in research and development is associated with the size of an enterprise (Zemplinerová, 2010). Empirical studies suggest connections between the market structure and enterprise size and the potential for innovativeness (Cohen, 2010).

The simplified original Cobb-Douglas model can be construed as a model consisting of several equations which address the problem of the selectivity of innovations, and of the co-dependence of the productivity of innovations (Lööf & Heshmati, 2002). In the source literature, the Cobb-Douglas model has been presented for Norway, France and Sweden (Lööf & Heshmati, 2003; Janz et al,. 2004). However, regression dependence of the sold production of new and significantly improved goods in streams (expenditure) on real and human capital in Polish industry in the years 2005-2007, 2008-2010 and 2011-2013 has not been determined so far. The empirical study presented herein aims to fill this gap.

3. Material and methods

Correlating independent variables requires the appropriate approach to the quantification of individual variables. As a result, individual variables have to be defined appropriately.

The following empirical variables have been considered:

Y – value of the sold production of new and significantly improved goods,

x_1 – expenditure (value) on research and development activities,

x_2 – expenditure (value) on knowledge from external sources and software,

x_3 – expenditure (value) on buildings and installations, and on land,

x_4 – expenditure (value) on machinery, technical equipment and tools, as well as on means of transport,

x_5 – expenditure (value) on training and marketing,

$x_6 - (x_2 + x_5)$, correlating logarithms x_2 and x_5 with Y, the same and decreases over time, while x_6 greater by 10%,

$x_7 - (x_3 + x_4)$, correlating logarithms x_3 and x_4 with Y – x_4 greater by 10%, while x_7 with Y increases by over 10%,

$x_8 - (x_1 + x_2 + x_5)$, correlating logarithms x_1, x_2 and x_5 – similar and decreases over time, while in relation to Y, similar and decreases over time, while x_8 with Y stable and increasing to 10%.

The correlation among independent variables, as well as between each of them, and the dependent variable (Y) were established using the matrix of logarithm correlation and coefficients of logarithm correlation at the significance level $p<0.05$; N = 48 in each sub-period.

The following Cobb-Douglas curvilinear power production function was proposed:

$$Y = ax_1^b x_2^c x_3^d x_4^e x_5^f \varepsilon \quad (1).$$

This dependence can also be expressed as:

$$Y = ax_1^b x_2^c x_5^f x_7^h, \text{ where: } x_7 = x_3 + x_4 \quad (3)$$

$$\text{or: } Y = ax_7^h x_8^i, \text{ where: } x_8 = x_1 + x_2 + x_5 \quad (4)$$

All these equations are equivalent; while correlations among independent variables in the equations above vary.

The subject of the estimation of logarithmized empirical data using the Least Squares Method is the value of the sold production of new and significantly improved goods and of its aggregated innovative expenditure in Polish industry in the years 2005-2007, 2008-2010 and 2011-2013. The aim of redefining independent variables is the preservation of their interpretative sense with their simultaneous higher correlation with the dependent variable, and lower correlation among independent variables. This principle is the basis for obtaining a good regression. As a result of redefining the expenditure (streams) of the independent variable x_7 and x_8 (4), expenditure streams are put together towards maintaining the sense of implementation of the real and human capital category, and their regression dependence on the value of sold production of new and significantly improved goods in Polish industry in the years 2005-2007, 2008-2010 and 2011-2013.

The randomness of the random component distribution has been examined using graphic analysis and the runs test, at the significance level 0.05. Both the graphic analysis and the runs test confirmed the verification of the hypothesis, assuming the validity of the selection of the analytical form of the obtained models presented in table 2. The random component normality was examined using the Kolmogorov-Liliefors test. The values resulting from calculations, when compared with critical values at the significance level 0.05 in the years 2005-2007, 2008-2010 and 2011-2013, did not justify the rejection of the hypothesis that the distribution of the random component was normal. Autocorrelation was examined by the Durbin-Watson test; based on its results, the lack of autocorrelation of the random component was determined, at the significance level 0.05. The hypothesis of the random component homoscedasticity was verified by the Goldfeld-Quandt test. At the adopted significance level 0.05, the read critical value of Snedecor's F-distribution exceeded the calculated value; as a result, there was

no basis for the rejection of the hypothesis of the random component homoscedasticity (Aczel, 2002).

4. Characteristics of empirical data sets

The study was performed based on the empirical data sets for all provinces (N=48) in Poland in the years 2005-2007, 2008-2010 and 2011-2013. The values of the characteristics of individual data set elements by prices in 2005 were got to comparability. On this basis, it is possible to compare the characteristics among the sets in the periods of years and obtained function parameters, in the result of estimation. The statistical characteristics of the parameters of variables are presented in table 1.

The objective of the activities in the scope of process and product innovations in Polish industry is to introduce new and significantly improved goods to the market. The average level of the value of the sold production of the aforementioned resources in Polish industry in the years 2005-2007, 2008-2010 and 2011-2013 decreases successively (table 1). The value range of the sold production of new and significantly improved goods characteristic in the period examined decreases similarly. This character of changes results in decreasing internal variability of the sold production of new and significantly improved goods in the period examined.

The average level of expenditure (values) on buildings and installations, land, machinery, technical equipment and tools, as well as on means of transport does not change significantly in the period examined. The character of changes in the value range (extremum) of the aforementioned expenditure is similar. As a result of the character of changes described above the internal variability of this expenditure does not change in the periods of years. These aggregated expenditure (streams) constitutes the innovative real capital of Polish industry in the examined periods of years.

Table 1: Parameters of variable characteristics in the scope of product and process innovations in Polish industry in the years 2005-2007, 2008-2010, and 2011-2013 (fixed prices, 2005)

Specification	Years	Symbol	Unit of measurement	Arithmetic mean	Range min.-max.	Variation coefficient %
Sold production of new and significantly improved goods	2005-2007 2008-2010 2011-2013	Y	PLN million	8319.2 7373.6 7156.0	670.7-47343.7 788.6-32070.5 629.3-28920.3	131.7 108.4 112.9
Expenditure (value) on buildings and installations, land, machinery, technical equipment and tools, as well as on means of transport	2005-2007 2008-2010 2011-2013	x_7	PLN million	882.9 1021.9 977.6	112.7-4116.2 153.9-4482.1 127.9-3978.4	102.3 100.0 98.2
Expenditure (value) on research and development activities, knowledge from external sources, software, as well as on training and marketing	2005-2007 2008-2010 2011-2013	x_8	PLN million	150.3 221.7 341.4	7.2-730.5 8.2-1221.1 20.4-1890.7	117.9 127.0 120.8

Source: Statistical Yearbook of Industry. Central Statistical Office, Warsaw 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014. Poland. Author's calculations.

The character of changes is slightly different in the case of expenditure (values) on research and development activities, knowledge from external sources and software, as well as on training and marketing. The average level of this expenditure increases; so does the range of this expenditure. As a result of these changes, the internal variability of this expenditure on the period examined increases by nearly 20 percentage points. However, this difference is not large enough to have a significant impact on changes in the level of the sold production of new and significantly improved goods in Polish industry in the period examined. It has to be noted that the above expenditure (streams) determine the value of creating the potential of human capital in Polish industry. The risk and

uncertainty of the implementation of expenditure on research and development may be limited due to the application of the open (market) innovations model (Chesbrongh, 2010).

5. Production vs real and human capital

Building the innovative potential is related to the economic activity in a given country. These preconditions are present in the empirical data sets, which in turn are expressed as fixed prices in 2005, while their regression dependence was expressed as Cobb-Douglas functions with their statistical evaluations. This curvilinear regression dependence is presented in tabular form in table 2.

Data in table 2 present the regression dependence of the values of the sold production of new and significantly improved goods (Y) from expenditure (values) on buildings and installations, land, machinery, technical equipment and tools, means of transport (x_7), as well as expenditure (values) on research and development activities, knowledge from external sources, software, and on training and marketing (x_8). The aforementioned variables, when aggregated (x_7 and x_8), explain the variability of the values of sold innovative production in industry in the years 2005-2007 (in 71%), 2008-2010 (in 84%), and in 2011-2013 (in 67%). Value regression expressed as the coefficient of determination (R^2), above 0.9 – very good, above 0.8 – good, and above 0.6 – satisfactory (Neumark, Tinsley & Tosini, 1991). The higher the R^2, the better the matching, and the higher the confidence in regression. The remaining unexplained variability of the values of the sold innovative production is the share of the variables which were not taken into account in the study. The strength of association, described with the multiple correlation coefficient (R), between the value of the sold production of new and significantly improved goods and the expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport, as well as the expenditure on research and development activities, knowledge from external sources, software, and on training and marketing, as the positive root of R^2 is 84% for the years 2005-2007, 92% for the years 2008-2010, and 82% for the years 2011-2013. Sheskin (2004) distinguishes: in the range 0.10-0.39 – poor correlation, 0.40-0.69 – average correlation, 0.70-0.89 - strong correlation and 0.90-1.00 – very strong correlation. Correlation is not a causal relationship. Therefore, in this study the regression dependence was examined. Standard errors of regression coefficients (parameters) are lower than 50% of their absolute value. A the same time, the absolute values of the t test are several times higher than the values of regression coefficients, while the significance level of regression coefficients is within the 0.00-0.05 range. The statistical evaluation of regression coefficients (parameters) informs about the possibility to use them in the econometric analysis of the variability of the values of sold production of new and significantly improved goods in Polish industry in the years 2005-2007, 2008-2010, and 2011-2013.

Table 2: Power regression of the sold production of new and significantly improved goods (Y) from expenditure on buildings and installations, land and machinery, technical equipment and tools, as well as means of transport (x_7), and expenditure on research and development activities, knowledge from external sources, software, as well as training and marketing (x_8) in Polish industry in the years 2005-2007, 2008-2010, and 2011-2013 (prices in 2005)

Years	a*	Regression coefficient		Standard error			Test t			Significance level			R^2
		x_7	x_8	a	x_7	x_8	a	x_7	x_8	a	x_7	x_8	
2005-2007	19.767 (2.984)	0.646	0.297	0.90	0.21	0.14	3.2	3.0	2.2	0.00	0.00	0.03	0.71
2008-2010	0.178 (-1.728)	0.517	0.709	0.78	0.09	0.15	-2.2	5.5	4.6	0.03	0.00	0.00	0.84
2011-2013	5.038 (1.617)	0.868	0.190	0.77	0.18	0.09	2.1	4.7	2.3	0.04	0.00	0.05	0.67

Source: Statistical Yearbook of Industry. Central Statistical Office, Warsaw 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014. Poland. Author's own numerical calculations.
*a –constant of equation delogarithmized (absolute term).

Regression coefficients, function parameters at x_7 and x_8 describe the flexibility (flexibility coefficients) of the values of sold production of new and significantly improved goods in relation to

expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport, as well as expenditure on research and development activities, knowledge from external sources, software, and on training and marketing. Solow (1956) explains that they are flexibilities of Y in relation to x_7 and x_8 and according to the marginal theory of distribution by J.B. Clark, they are the shares of innovative input of these factors (x_7 and x_8) in output (in the sold innovative production).

The flexibility of the value of the sold production of new and significantly improved goods (table 2) is higher in relation to expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport (0.646 in the years 2005-2007 and 0.868 in the years 2011-2013) than expenditure on research and development activities, knowledge from external sources, software, and on training and marketing (0.297 in the years 2005-2007 and 0.190 in the years 2011-2013). The former expenditure constitutes the streams of real capital, while the latter constitute streams of human capital. At the same time, in the years 2008-2010 the flexibility of the value of sold production of new and significantly improved goods (table 2) is higher in relation to expenditure on research and development activities, knowledge from external sources, software, and on training and marketing (0.709) than expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport (0.517).

It results from the relation of regression coefficients (flexibility coefficients) that the sold production of new and significantly improved goods in relation to expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport is over 2 times (2005-2007) and over 4.5 times (2011-2013) higher than expenditure on research and development activities, knowledge from external sources, software, and on training and marketing. At the same time, flexibility of the sold production of new and significantly improved goods in relation to expenditure on research and development activities, knowledge from external sources, software, as well as on training and marketing is almost 1.4 times higher than expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport in the years 2008-2010. However, it has to be stressed that the decisions concerning the implementation of real capital are shaped by the environment of a given entity (Rostášová & Chrenková, 2010), and therefore they do not depend on the decisions of individual economic entities. So, the main independent variable in the conducted studies is the growth of expenditure on human capital. Human capital is characterized by particular specifics and an individual specific mechanism, and due to this mechanism the flexibility of the sold production of new and significantly improved goods in relation to human capital is only a part of the general output. It results from the theory of innovativeness growth rate calculated on the basis of the Cobb-Douglas regression, where the growth rate of innovations is a variable dependent on real and human capital, that assuming the specified level of the growth rate flexibility in relation to real capital, the growth rate flexibility in relation to human capital van be equal to unity. It results from the logical interpretations of the innovation growth rate model (theory) described above that at the specified examined technical level of Polish industry, the impact of the streams of expenditure on human capital is utilized at 29.7% (2005-2007), 70.9% (2008-2010), and at 19% (2011-2013) in relation to the potential capabilities of the human capital impact (theory). The stepwise increase in the flexibility of sold production of new and significantly improved goods in relation to human capital in the years 2008-2010 (70.9%) (the higher influence of human capital about 15,6 the proportional point in relation to factual), regressed in the years 2011-2013 (19%).

Human capital is an advantage of the Polish economy, but it is not utilized to its full potential. The reason is the very small number of innovative enterprises in the Polish economy. The study results described above demonstrate that there is an imbalance in the relative impact of the streams of real and human capital on the increase in the sold production of new and significantly improved goods in Polish industry in the period examined. This deep imbalance does not occur in innovative economies where all dimensions (streams) of the innovativeness potential in their installations are of significance for the effective use of this potential. (Galvez et al., 2013).

It results from the innovation growth rate model (Cobb-Douglas) that the flexibility of the values of innovations' production in relation to real capital should be less than unity. It results from the studies described above that it is less than unity and equals 64.6% (2005-2007), 51.7% (2008-2010), and 86.8% (2011-2013). The strongest impact on the increase in values of the sold production of new and significantly improved goods is exerted by the expenditure on buildings and installations, land, machinery, technical equipment and tools, and on

means of transport, which constitute the passive transfer of technologies to enterprises. The expenditure mentioned above is the main area of implementation in Polish industry and a typical phenomenon in the Polish economy.

It results from the sum of flexibility coefficients (powers) (table 2) in the years 2005-2007, which is close to unity (0.943), that the sold production of new and significantly improved goods in relation to the combined impact of expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport and expenditure on research and development activities, knowledge from external sources, software, and on training and marketing increases almost proportionally at the relatively constant level of other expenditure. Here we can talk about almost constant economies of scale. Thus, the character of the discussed model is close to the homogeneous function, meaning a function where both the expenditure of factors and the effects increase by almost the same percentage (1%).

In turn, it results from the sum of flexibility coefficients (table 2) greater than unity in the years 2008-2010 (1,226), and 2011-2013 (1,058) that the sold production of new and significantly improved goods in relation to the combined impact of expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport and in research and development activities, knowledge from external sources, software, and on training and marketing increases more than proportionally at the relatively constant level of other expenditure. There is more than proportional growth in the sold production of new and significantly improved goods resulting from the proportional increase in real and human capital, at the relatively constant level of other expenditure on Polish industry in the years 2008-2010 and 2011-2013. Therefore, there are increasing economies of scale.

The total increase in expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport, and in research and development activities, knowledge from external sources, software, and on training and marketing by 10% results in the increase in the sold production of new and significantly improved goods by 9.43% (2005-2007), 12.26% (2008-2010), and 10.58% (2011-2013).

The sold production of new and significantly improved goods has relatively constant marginal utility, and its markets are not subject to limitations resulting from the level of saturation; and with increasing demand and affordable prices the market of new and significantly improved goods dynamises the entire economic system (effect of scale, decreased production costs and prices). And the goods mentioned above may contribute to the emergence of new outlets. On the one hand, the market undergoes integration (is strengthened), while on the other hand it stimulates technological development (Oughton et al., 2002). Regional development needs innovations for gaining profits and building competitive positions in the global economy; it increases the effectiveness of innovation-based investments (Gillo et al., 2011).

It results from the proportion of impact (sum of flexibilities = 100%) (table 2) that the impact of expenditure on buildings and installations, land, machinery, technical equipment and tools, and on means of transport on the relative gain in the sold production of new and significantly improved goods is 68.5% (2005-2007), 42.2% (2008-2010), and 82% (2011-2013), while expenditure on research and development activities, knowledge from external sources, software, and in marketing is 31.5% (2005-2007), 57.8% (2008-2010), and 18% (2011-2013) in Polish industry. The innovative potential expresses the varying ability of industry to use resources effectively for new products and processes (Zizlavsky, 2011). This differentiation in the examined periods results from the stepwise growth of expenditure on real capital, and from the lack of adjustment of the streams of expenditure on human capital in Polish industry. The implementation of the low techniques did not involve expenditure on research and development, and this decreased expenditure could be the substitute of technological cooperation (Huang et al.,2010).

In simple terms, the parameters of the general effectiveness of the processes of sold production (absolute terms) in the examined periods decrease in relation to the combined impact of real and human capital. This suggests that the effectiveness of real and human capital decreases in the examined periods. Furthermore, this explains the deteriorated utilization of the streams of expenditure on real and human capital in Polish industry in the years 2005-2013

6. Conclusions

Hypothesis was confirmed, that the unfavourable proportions of human capital step out to factual capital in implementation of innovation in Polish industry.

As a result of estimation, the obtained function model parameters explained the variability of the sold production of new and significantly improved goods with real and human capital in the years

2005-2007 at 71%, in the years 2008-2010 at 84%, and in the years 2011-2013 at 67%. Thus, the obtained explanation remained in the range of satisfactory to good.

In the examined periods, in general, the flexibility of the sold production of new and significantly improved goods increases in relation to real capital – 0.646 (2005-2007), 0.517 (2008-2010), and 0.868 (2011-2013). This proves that the main innovations in Polish industry are implemented through the passive transfer of technologies like machinery and tools, as well as means of transport.

The flexibility of the sold production of new and significantly improved goods in relation to human capital changes stepwise with regression. This suggests that not all dimensions of human capital innovative potential are developed and utilized in Polish industry. This results from the fact that there weren't any specific associations in the structures of real and human capital in Polish industry. This poses the limit for obtaining more than proportional increases in the sold innovative production from the expenditure on real and human capital in Polish industry.

It results from the innovation growth rate flexibility in relation to human capital that it may equal unity (Cobb-Douglas model). This constitutes a potential limit to human capital flexibility. In relation to human capital flexibility, human capital was utilized only at 29.7% (2005-2007), 70.9% (2008-2010), and at 19% (2011-2013). Its stepwise utilization suggests the negative structuration of this capital, and its low application and utilization in Polish industry.

It results from the comparison of the parameters (absolute terms) of the general effectiveness of the processes of sold production in the examined periods that the combined effectiveness of real and human capital decreased in Polish industry in the years 2005-2013. This suggests the lack of coordination of the application of real and human capital expenditure streams in Polish industry.

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