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MARIA GRZELAK*

Innovation Activity and Competitiveness of Manufacturing Divisions in Poland

Abstract

Increasing processes of globalization and integration in the world economy, dynamic market changes and growing social demands cause that particular sections of the national economy and their divisions as well as enterprises operating in them, become more and more often participants of competitive activity.

According to M. Porter getting competitive advantage is possible only by means of innovation activity, and the capacity of industry for innovation and increasing technological level decide about competitiveness of the whole economy. That is why in present-day economic researches it is so important to define relations between competitiveness and innovation activity of enterprises.

The objective of the article is an attempt to describe quantitatively the impact of outlays on research and development and outlays on innovation on three selected characteristics defining competitiveness of manufacturing enterprises. These characteristics are: gross value added, sold production and labour productivity.

In the research were used statistical data of Central Statistical Office showing amounts of particular types of outlays divided into particular manufacturing divisions (section D, the Polish Classification of Activities) in the period 1999-2008. the analysis was conducted by means of panel models, where the basic period is calendar year, and the objects are manufacturing divisions on two-digit level of aggregation.

* Ph. D., University of Łódź

1. Introduction

In modern researches and economic discussions a lot of attention is paid to issues of relations among competitiveness, research and development capacity (R&D) and innovation. In theoretical researches concerning relations between the mentioned categories more and more often attention is paid to the use of modern research procedures, and especially to methods of present-day econometrics.

Measurement of research and development as well as of innovation capacity, although extremely difficult, is important to authorities determining the level of outlays on R&D and the way of public spending, also to enterprises assessing expected profits from R&D activity and innovation.

The objective of the article is an attempt to estimate the impact of innovation activity and competitiveness of particular manufacturing divisions in Poland. The starting point of formulating this estimation are models of economic growth taking into account technological progress and having the classical form of Cobb-Douglass production function as the basis of their construction (Welfe 2000).

On the basis of the theory it was proved that achieving competitive advantage is possible only by means of innovative activities and the capacity of industry for innovation and increasing technological level decide about competitiveness of the whole economy (Porter 1990). Then the competitive position of manufacturing firms and of the whole economy results in a considerable degree from implementing into the economic process achievements of science in the form of new, better solutions concerning production means and manufacturing methods. According to M. Porter, the impact of innovation activity of manufacturing divisions on their competitiveness is reflected in labour productivity and capital. Permanent increase of effectiveness, defined by M. Porter as value generated per unit of labour or capital, requires continuous progress in economy, that is introduction of innovation. Increasing effectiveness of divisions is possible through improvement of the quality of products, their modification and improvement of technology. It means that innovation leads to the change of competitive advantages which is finally reflected in variation in productivity of production factors. It seems then that in a short period improvement of competitiveness of manufacturing divisions is reflected in the increase of sold production value, while in a long period in the increase of productivity.

The main causes of considerable differentiation of the innovation level of manufacturing divisions are different expenditures on R&D and innovation activity of the given division, the level and structure of employment as well as organization and cooperation in innovation activity. Research and development activity means systematically conducted creative work comprising basic, applied and developmental researches. R&D activity differs from other kinds of activity on a perceptible element of novelty and elimination of scientific and/or technological uncertainty, that is a solution of the problem which does not result obviously from the existing state of knowledge (Science and Technology 2009, p. 36). It can contribute to the increase in production, labour productivity or through its contribution to the product innovation which improves parameters of products, or also process innovation which improves manufacturing technology and reduces the share of parts (raw materials, components and so on) per unit of production. Whereas innovation activity is a series of activities of scientific (research), technological, organizational, financial and commercial activities, which aim is to develop and implement new or considerably improved products and processes, assuming these products and processes are new at least from the point of view of the enterprise introducing them (Science and Technology 2009, p. 119). Therefore, innovation activity is conducted in a discontinuous way and aims to solve current problems and purchase of R&D services from other entities. Outlays on innovation are means destined for implementation of a new idea expended on material technology, buildings and structures, implementation and tests, also on marketing of innovation and training of personnel. In the process of innovation on the level of enterprises both mentioned types of innovation are closely correlated. Enterprises very seldom introduce new products without changing manufacturing process. Moreover, when a product is a means of production, then the product innovation – from the point of view of one industry – is product innovation from the point of view of another – and changes of the product and the process of its manufacturing are correlated. In the economic researches both types of innovation are described in the categories of activity reducing costs. The reduction of manufacturing costs makes profit from investments in R&D activity. Making decisions to finance R&D researches and innovation activity an enterprise is guided by the expected profitability, that is by broadly understood motive of profit. The size of the profit is expressed among others by the size of sale demand for innovation and costs of manufacturing innovation. With gaining profit another motive of innovation activity of an enterprise is connected, namely the intention of increasing its share in the market. One of the mentioned symptoms of improvement in the position on the market is growing dynamic of sold production.

In the light of the above considerations it seems sensible to estimate the impact of innovation on competitiveness of manufacturing divisions in Poland, on one hand we should consider the level of expenditures of enterprises of a given division on R&D and innovation activity treating them as outlays to create and implement new solutions, while on the other hand the achieved results measured by changes of value added, indices of sold production and changes in productivity (Witkowski, Weresa 2006, p. 2002-2003).

Modelling of the discussed relations should be preceded by statistical and descriptive estimation of indicators adopted to assess the relation of innovativeness and competitiveness of divisions.

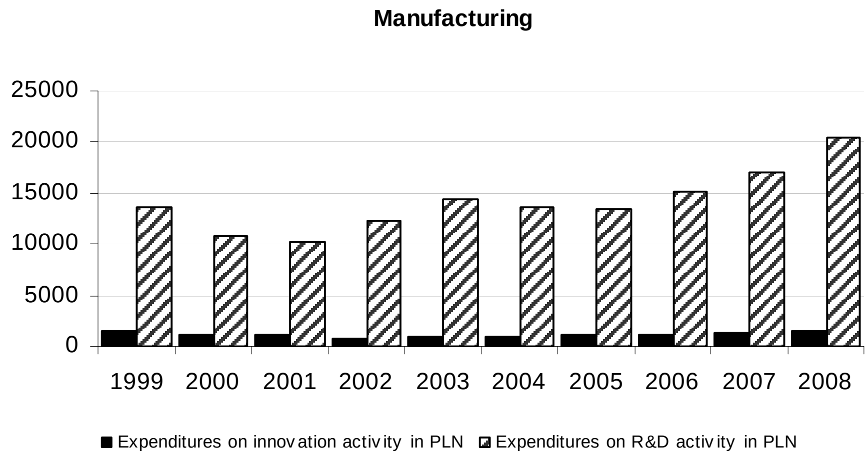
2. Expenditures on R&D and innovation in manufacturing enterprises

In the years 1999-2008 expenditures on R&D activity in manufacturing enterprises in which the number of employees exceeded 49, increased nominally from 1471,6 to 1508,7 mln zloty (the increase of 2,5%) and came from different sources (GUS 2000 and 2009). However, expressing the above expenditures in constant prices from the year 2005 it turns out that on the average from year to year expenditures on R&D decreased by 3%. In 2008 the most important are own expenditures of enterprises which accounted for 83,9% of the total expenditures on R&D, then expenditures from the state budget 6,2% and foreign outlays 4,5%.

The structure of assigning outlays for particular manufacturing divisions is strongly differentiated. The biggest share in the total value of outlays on R&D have the following divisions: manufacture of chemical products (28,9%), manufacture of electrical machinery and apparatus (12,2%), manufacture of motor vehicles, trailers and semi-trailers (11,6%), manufacture of machinery and equipment (10,6%), manufacture of food products (6,8%). In the other divisions the share of these expenditures does not exceed 6%. The smallest percentage of total expenditures on R&D is in: manufacture of coke and refined petroleum products (0,4%), manufacture of wood, straw and wicker products (0,4%), manufacture of office machinery and computers (0,4%), manufacture of furniture, manufacturing n.e.c. (0,6%), publishing, printing and reproduction of recorded media (0,6%).

Indices of expenditures on innovation activity were decisively bigger than indices of expenditures on R&D. In the years 1999-2008 expenditures on innovation activity in nominal approach increased by over 50% (from 13564,2 mln zl in 1999 to 20454,8 mln zl in 2008), while in fact the increase accounted for 13,6%. The average annual rate of increase in expenditures on innovation (in constant prices 2005=100) accounted for 1,4%. The division structure of expenditures on innovation in manufacturing enterprises is also different. The divisions with the highest share in the total amount spent by manufacturing enterprises on innovation are the following: manufacture of motor vehicles trailers and semi-trailers (11,7%), manufacture of food products (9,9%), manufacture of chemicals and chemical products (7,3%). The divisions characterized by the smallest share of below 1% in expenditures on innovation are: manufacture of clothes and furriery (0,05%), manufacture of leather and of leather products (0,1%), manufacture of tobacco products (0,4%), manufacture of office machinery and computers (0,5%), manufacture of textiles (0,6%). Total expenditures on innovation activity in manufacturing enterprises in 2008 accounted for 20454,8 mln zl and were thirteen times higher than expenditures on R&D activity. It means that enterprises are considerably more interested in innovation activity that brings quick market effects than in conducting systematic, long-term researches.

Diagram 1. Expenditures on R&D and on innovation in manufacturing enterprises in the period 1999-2008



Source: own research based on General Statistic Office data.

In 2008 in manufacturing the structure of expenditures on innovation activity is dominated by capital expenditures on purchase of machinery, technological equipment and means of transport, also capital expenditures on buildings and structures (26,2%). The remaining part of capital expenditures is spent on R&D activity (9,5%), marketing of new or significantly improved products (2,9%), purchase of new ready technology in the form of documentation and rights (1,2%), also on training of personnel related to innovation activity (0,4%).

Table 1 and 2 present the ranking of manufacturing divisions considering their share in total expenditures of manufacturing on R&D/innovation. The presented ranking shows only six first positions.

Table 1. Specification of manufacturing divisions taking the six first positions considering the share of their expenditures on R&D in expenditures on R&D of manufacturing in total (in %)

Position	Name of the division	Share of expenditures on R&D (%)
1.	Manufacture of chemicals and chemical products	28,9
2.	Manufacture of electrical machinery and apparatus n.e.c.	12,2
3.	Manufacture of motor vehicles, trailers and semi-trailers	11,6
4.	Manufacture of machinery and equipment n.e.c.	10,6
5.	Manufacture of metal products excluding machinery and equipment	9,5
6.	Manufacture of food products and beverages	6,8

Source: own research based on General Statistic Office data.

Table 2. Specification of manufacturing divisions taking the six first positions considering their share in expenditures on innovation in expenditures on innovation of manufacturing in total (in %)

Position	Name of the division	Share of expenditures on R&D (%)
1.	Manufacture of motor vehicles, trailers and semi-trailers	11,7
2.	Manufacture of food products and beverages	9,9
3.	Manufacture of chemicals and chemical products	7,3
4.	Manufacture of other non-metalic mineral products	6,7
5.	Manufacture of metal products, excluding machinery and equipment	6,3
6.	Manufacture of basic metals	6,2

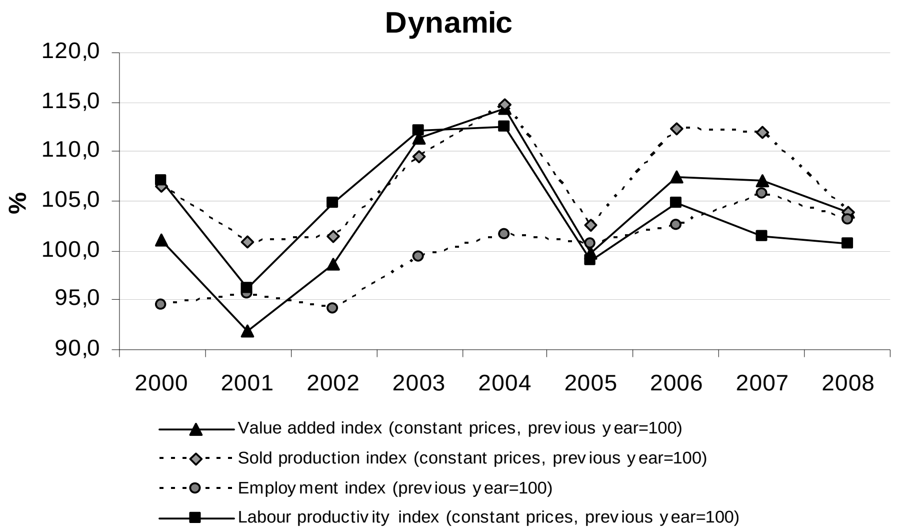
Source: own research based on general Statistic Office data.

From the comparison of structures of expenditures on innovation it results that only three divisions show relatively large shares in both kinds of expenditures. They are manufacture of motor vehicles, trailers and semi-trailers, manufacture of chemicals and chemical products and manufacture of food products. In these divisions an important role is played by firms with foreign capital, which proves a positive impact of foreign direct investments on the process of modernizing and innovation of manufacturing.

3. Value added, sold production and labour productivity in manufacturing

The analysis of the impact of innovation on competitiveness of manufacturing division requires comparison of economic results of these divisions. To estimate competitiveness of manufacturing divisions we will use three basic indices: value added, sold production and labour productivity measured by value added per an employed person. These three indices for the manufacturing section are illustrated by diagram 2.

Diagram 2. Indices of value added, sold production and labour productivity in the manufacturing section in the years 1999-2008 (constant prices, previous year=100)



Source: own research based on General Statistic Office data.

The comparison of the rate of changes in the researched categories shows that while maintaining the same direction of changes there occurred a considerable difference of the rate of their rise or fall. In the years 1999-2008 the rate of labour productivity changes was in general increasing, the average annual productivity was growing by 4,1%. Only in 2001 and 2002 there were falls in labour productivity, in 2002 this decline was significant and accounted for almost 4%. Indices of value added were different regarding both the direction and the rate of changes. In the years 2001, 2002 and 2005 there occurred falls in this category in comparison with the previous year respectively of 8,1%, 1,4% and -0,3%. On the average per year in the researched years value added increased by 3,7%. Attention should be paid to the fact that in the whole researched period only sold production was characterized by increase from year to year, on average this increase accounted for 7% per year. The highest rate of increase occurred in 2004. The year 2004 should be recognized as an exceptional one because the increase rate of all the three examined indices was the biggest and so sold production was higher than the noted one in 2003 by as much 14,8%, value added by 14,4% and labour productivity by 12,4%. It is worth noticing that in the years 1999-2003 the increase of sold production of manufacturing was accompanied by the decrease of employment which was stopped in 2004. In the following year employment was growing from year to year, but all the time its rate of growth was lower than the rate of sold production increase, and in 2006-2008 also than value added.

The highest average annual rate of increase in labour productivity occurred in the analyzed years 1999-2008 in the divisions: manufacture of coke, refined petroleum and derivatives (the average annual increase of 15%), manufacture of basic metals (11%), manufacture of motor vehicles, trailers and semi-trailers (9%). Whereas gross value added was characterized by the biggest average annual dynamic of increase in the following manufacturing divisions: manufacture of motor vehicles, trailers and semi-trailers (13%), manufacture of coke refined petroleum and derivatives (11%), manufacture of metal products except machinery and equipment (8%). The highest average rate of changes of sold production is noted in the division of recycling (14%), manufacture of metal products except machinery and equipment (12%), manufacture of coke, refined petroleum products and derivatives (12%), manufacture of motor vehicles, trailers and semi-trailers (11%). Comparing the average annual rates of increase in indices characterizing in our research competitiveness of manufacturing divisions we notice that two divisions, manufacture of coke, refined petroleum products and derivates as well as manufacture of motor vehicles, trailers and semi-trailers stand out on the background of the others. They are characterized by high dynamic of increase of all the three indices of competitiveness, namely labour productivity, gross value added and sold production. Whereas employment in these divisions was characterized by the same rate, but by different direction of these changes. In case of manufacture of coke refined petroleum products and derivatives there was an average annual fall in employment by 4%, while in manufacture of motor vehicles, trailers and semi-trailers there was an average annual increase in employment of 4%. It means that improvement of competitiveness in these divisions results mainly from implemented in the processes of production changes in technology and organization manifested in the introduction of innovation.

4. Evaluation of relations between innovation and competitiveness of manufacturing divisions

In this part of the article an attempt was made to describe quantatively the impact of expenditures on research and development and expenditures on innovation on three selected characteristics defining competitiveness of manufacturing enterprises. These characteristics are: gross value added, sold production and labour productivity. The research used published by Central Statistical Office data concerning amounts of particular types of expenditures divided into particular divisions of manufacturing (section D the Polish Classification of Activities) in the years 1999-2008. Taking into account heterogeneity of particular divisions it seems optimal to conduct the analysis based on time series, separate for each of them, however data comprising a ten-year period cause that the analysis based on such short time series is of little credibility for particular divisions. In such a situation the best solution is to treat the possessed data as a panel in which a calendar year is a basic period and manufacturing divisions are objects.

According to the Polish Classification of Activities (PKD) the research will comprise manufacturing divisions (section D) on the two-digit level of aggregation:

Table 3. Manufacturing divisions in accordance with the Polish Classification of Activities

Polish Classification of Activities	Name of division
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel and furriery
19	Manufacture of leather and of leather products
20	Manufacture of wood, wood straw and cork products (except furniture) and plaiting materials
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
27	Manufacture of basic metals
28	Manufacture of metal products except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office machinery and computers
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
36	Manufacture of furniture, manufacturing n.e.c
37	Recycling

Source: own research.

Regarding the classification of the manufacturing section applied by Central Statistical Office, in the research, due to considerable lack of data, were left out according to the tested model two (manufacture of office machinery and computers (30), recycling (37) or six divisions (manufacture of office machinery and computers (30), recycling (37), manufacture of tobacco products (16), manufacture of wearing apparel and furriery (18), processing of leather and manufacture of leather products (19), manufacture of pulp paper and paper products (21)).

Therefore the panel contains the data concerning 21 or 17 divisions of manufacturing in the period 1999-2008 (respectively 210 and 170 observations).

Consequently the analysis will be conducted on the mezoeconomic level and concern entities in which the number of employees exceeds 49 persons and research &development entities working for industry (Statistical Yearbook of Industry 2009, p. 451).

5. Specification of the models

Panel models may have the forms: Fixed Effects Model (FEM) or Random Effects Model (REM), assuming decomposition may take into account only one factor (one-factor models) or two factors simultaneously (two-factor models).

The models FEM and REM may be generally recorded[1]:

$$y_{it} = m_i + bx_{it} + e_{it} \quad 2)$$

where:

m_i – general absolute term,

b – structural parameter expressing the influence of the descriptive variable x,

x_{it} – realization of the descriptive variable for i-of this object in t-of this period,

e_{it} – remainders, fulfilling classical assumptions: $E(e_{it}) = 0$ and $Var(e_{it}) = S_e^2$.

In the FEM model m_i is decomposed into free terms (absolute) for particular groups separately. The model, then has the form (Suchecki 2000):

[1] To simplify the models with one descriptive variable were used, nevertheless the models can have the form with many variables.

$$y_{it} = a_1 d_{1it} + a_2 d_{2it} + ... + a_k d_{kit} + bx_{it} + e_{it} = a_i + bx_{it} + e_{it}, \quad (3)$$

where:

ai – specific free terms, while

di zero-one variables adopting the value 1,

if j = i.

In the REM model m_i expresses specific random components. The model can be recorded in the following form [Green 2008]:

$$y_{it} = a + bx_{it} + e_{it} + u_i, \quad (4)$$

where:

E(ui) = 0,

Var(ui) = S_e^2 *,*

Cov(eit, ui) = 0.

The estimation of the model is based on chi-square statistics founded on Likelihood Ratio Test (LRT) and F statistics (counted traditionally on the ground of sum of squared deviations). For the model REM Lagrange Multiplier test is conducted and its test statistics is LMT (Lagrange Multiplier Test statistic). With low p (the adopted level of validity α, α=0,05 is generally adopted) validity of the free term or random term decomposition is recognized. The choice between the models FEM and REM is conducted by means of Hausman test (at p<0,05 the FEM model is assented to be more reliable than REM) (Hausman 1978; Hausman, Taylor 1981). To estimate model parameters Limdep 7.0. software was applied.

6. Empirical outcomes of the gross value added model

Gross value added, according to the theory of economics, is in principle a category defining production value in particular manufacturing divisions. Choosing a suitable functional form of the gross value added model an attempt was made to describe this category by means of one of the classic models of production function. A good choice of the model from the point of view of the theory and adjustment was Cobb-Douglas multi-variable function of production and basing the model on the data from many years permitted to introduce a dynamic factor whose role is performed by the time variable adopting the value one in 1999 and increasing by 1 from year to year. Alternative to the introduction of time variable could be making decomposition of the random component for the factor “time”, however the introduction of the time variable will have greater number of freedom degrees in comparison with the model of decomposition of random component for this factor.

Originally conducting estimation of value added function both linear and exponential functional form of the model were adopted. According to the adopted assumptions, finally the exponential form was adopted, especially because the outcomes of estimation (expressed by determination co-efficient) did not differ fundamentally in comparison to the corresponding with the given equation linear form. Due to the fact that better outcomes of estimations were in case of fixed effects models than in random effects models (which was indicated by at least by the values of R^2, and above all by the outcomes of the Hausman test) the article presents only one-factor models with decomposition of the absolute term. At the same time decomposition of the free term was conducted for the selected manufacturing divisions. In the research, as it was said earlier, innovation activity is in the first case described by the value of expenditures on R&D (model 1), and in the other by the value of expenditures on innovation (model 2). It is worth noticing that the impact of expenditure on innovation, if it exists, should appear in a relatively short time, it means in the year when the expenditures were incurred. Whereas the impact of expenditures on R&D on value added may appear no sooner than after two years. That is why in the following models of gross value added were also tested expenditures on R&D delayed by 1-3 years, and expenditures on innovation delayed by one year. However, the best statistic quality of models (measured by the degree of the variance explanation and importance of the parameter standing by this delayed variable) was obtained in case of lack of delays. Having in mind the above observations in the research the following functions of value added were taken into account:

model 1

$$LnWdodbr_{it} = a_i + b_0 + b_1 LnZatr_{it} + b_2 LnNinw_{it} + b_3 LnB + R_{it} + b_4 t \qquad (5)$$

model 2

$$LnWdodbr_{it} = a_i + b_0 + b_1 LnZatr_{it} + b_2 LnNinw_{it} + b_3 LnInnow_{it} + b_4 t \qquad (6)$$

where:

$LnWdodbr_{it}$ - natural logarithm of gross value added in constant prices in mln zl from the year 2005 (to make the data real the price index of GDP Central Statistical Office) was applied for i-of this division of manufacturing in the year t;

$LnZatr_{it}$ - natural logarithm of average employment in thous. of employed persons for i-of this manufacturing division in the year t;

$LnNinw_{it}$ - natural logarithm of investment expenditures in constant prices in mln zl from the year 2005 (to make the data real investment expenditures index of Central Statistical Office was used);

$LnB + R_{it}$ - natural logarithm of value of R&D outlays in constant prices, in mln zl of 2005 (to make the data real the price index of GDP Central Statistical Office);

$LnInnow_{it}$ - natural logarithm of the value of expenditures on innovation in constant prices in mln zl from the year 2005 (to make the data real investment expenditures index of Central Statistical Office was used);

t – time variable, adopting the value of 1 in the year 1999, increasing by 1 per year;

a_i - specific free term, constant in time for the given division, fluctuating between divisions (the so called individual effect).

The estimation results of value added model, in which the role of productive factors is played by the size of employment, the amount of investment expenditures and the amount of expenditures on research and development are presented in table 4.

Table 4. The results of parameters estimation of the one-factor models describing the formation of gross value added in manufacturing (LnWdodbr) – model 1

Variable	**Co-efficient**	***t***	***p***	**Co-efficient**	***t***	***p***
	model (1.1.a)			**model (1. 1.b)**		
LnZatr	0,392	2,480	0,0142	0,427	2,842	0,0050
lnNinw	0,132	2,138	0,0340	0,131	2,123	0,0353
LnB+R	0,242	0,741	0,4600	-	-	-
t	0,352	5,163	0,0000	0,353	5,188	0,0000
Constant	-	-	-	-	-	-
R^2	0,9063			0,9060		
Evaluation of group effects significance	LRT= 142,983, p=0,0000; F= 12,282, p=0,0000			LRT=144,265, p=0,0000; F=12,529, p=0,0000		

t – value of t-Student's statistics, on the basis of which statistical significance of model parameters (coefficients) is estimated,

R^2 – coefficient of determination,

LRT – statistics of LRT test (*Likelihood Ratio Test),*

F – Fisher-Snedecor test statistics,

p – test probability ($p \in [0,1]$).

Source: own research based on Central Statistical Office data (Statistical Yearbooks for Industry 2000-2008).

Evaluating the influence of basic factors of production on value added of manufacturing significant and in line with expectations relations between examined variables were found out. Unfortunately, it does not concern the variable expenditures on R&D. Both employment and investments, also additional time variable show a positive impact on value added in manufacturing. We noted analogous tendencies in case of expenditures on R&D, but the impact of this variable turned out to be statistically insignificant (p=0.4600). as the results of estimation of model (1.1.b), deprived of the insignificant variable LnB+R show value added increases on average:

- by 0.427% together with the increase of employment of 1%,
- by 0.131% together with the increase of investment expenditures of 1%,
- on average per year by 3,5%.

It should be emphasized that group effects related to specificity of a given manufacturing division turned out to be significant. It is proved by very low, close to zero probability in LRT test or in F test. Moreover, the quality of the model estimated by means of common KMNK was considerably weaker (the coefficient of determination accounted for 0,7803).

Analyzing values of specific free terms estimated for particular manufacturing divisions we notice differences in their estimation – quite small, we should remember, however, that in the model both the variable explained as well as explanatory variables are logarithms which causes that we express changes of value added in per cent. High values of t statistics prove statistical significance of particular free terms.

Table 5. Values of specific free terms and corresponding with them statistics t

Manufacturing division	Model 1b	
	Co-efficient	t
Manufacture of food products and beverages	6,202	7,085
Manufacture of textiles	5,279	8,276
Manufacture of coke, refined petroleum products and fuel	6,118	12,398
Manufacture of chemicals and chemical products	6,097	8,861
Manufacture of rubber and plastic products	5,799	8,167
Manufacture of basic metals	5,575	8,686
Manufacture of metal products excluding machinery and equipment	6,022	7,859
Manufacture of machinery and apparatus n.e.c.	5,945	7,841
Manufacture of radio, television and communication equipment and apparatus	5,205	10,001
Manufacture of medical, precision and optical instruments, watches and clocks	5,601	10,455
Manufacture of motor vehicles, trailers and semi-trailers	5,714	8,260
Manufacture of furniture, manufacturing n.e.c.	5,631	7,659
Manufacture of wood, wood and cork products (excluding furniture), straw products and plaiting materials	5,592	8,096
Publishing, printing and reproduction of recorded media	6,075	9,462
Manufacture of other non-metalic mineral products	5,891	8,154
Manufacture of electrical machinery and apparatus n.e.c.	5,682	8,626
Manufacture of other transport equipment	5,420	8,777

Source: same as in table 4.

The highest values of specific free terms were noted for the divisions: manufacture of food products and beverages, manufacture of coke, refined petroleum products and fuels, manufacture of chemicals and chemical products, publishing, printing and reproduction of recorded media. The relatively weakest tendencies were noted for manufacture of radio television and communication equipment and apparatus, textile products, manufacture of other transport equipment.

It can be said, then, that in case of these divisions the effect of production factors is the strongest, value added growth is quicker at the background of other manufacturing divisions.

Table 6 contains in succession estimation results of gross value added model, in which descriptive variables are the size of employment, the amount of investment expenditures, the amount of expenditures on innovation and the time variable.

Table 6. Estimation results of one-factor models parameters describing development of gross value added in manufacturing (LnWdodbr) – model 2

Variable	Co-efficient	*t*	*p*	Co-efficient	*t*	*p*
	model (2.2.a)			Model (2.2.b)		
LnZatr	0,607	4,532	0,0000	0,607	4,540	0,0000
lnNinw	0,166	2,646	0,0088	0,156	2,719	0,0071
LnInnow	-0,168	-0,385	0,704	-	-	-
t	0,311	5,118	0,0000	0,312	5,139	0,0000
Constant						
R^2	0,9374			0,9374		
Evaluation of group effects significance	LRT=156,793, p=0,0000; F=10,266, p=0,0000			LRT=168,222, p=0,0000; F= 11,419, p=0,0000		

t – value of t-Student's statistics, on the basis of which statistical significance of model parameters (coefficients) is estimated,

R^2 – coefficient of determination,

LRT – statistics of LRT test (*Likelihood Ratio Test),*

F – Fisher-Snedecor test statistics,

p – test probability ($p \in [0,1]$).

Source: same as in table 4.

It is easy to notice that we cannot state a statistically significant impact of the variable *LnInnnow* (expenditures in innovation activity) on gross value added of particular manufacturing divisions. After removing the insignificant variable from the model statistical quality of the model and the values of co-efficient were slightly changed. It turns out that a 1% increase in employment results in the growth of value added of 0,607% on average, whereas an increase in investment expenditures of 1% results in the increase of value added of 0,156% on average. The evaluation of the parameter for the time variable t indicates the annual average increase in effectiveness of using production factors by 3,1%. Likewise in model 1, where innovation activity was expressed by expenditures on R&, also in this case group effects proved to be statistically significant. In the divisions: manufacture of coke, refined petroleum products and fuels, reproduction of recorded media and manufacture of chemicals and chemical products the highest values of specific free terms were noted. So, in these divisions occur the strongest positive tendencies in developing gross value added. The worse effects in this respect occur in the division of processing of leather and manufacture of leather products, manufacture of wearing apparel and furriery as well as in textile products. These are labour consuming divisions, characterized by generally lower effectiveness of production factors.

7. Empirical findings of the sold production model

To model sold production, likewise value added the Cobb-Douglas production function with time factor was used. The only difference between the models of value added and sold production is obviously another variable explained. Then the function of sold production value of manufacturing division adopts that depending on the kind of expenditures adopted to describe innovation activity (expenditures on R&D or innovation expenditures), the form:

model 1

$$LnPs_{it} = a_i + b_0 + b_1 LnZatr_{it} + b_2 LnNinw_{it} + b_3 LnB + R_{it} + b_4 t \qquad (7)$$

model 2

$$LnPs_{it} = a_i + b_0 + b_1 LnZatr_{it} + b_2 LnNinw_{it} + b_3 LnInnow_{it} + b_4 t\ , \qquad (8)$$

where $LnPs_{it}$ defines natural logarithm of sold production value in mln zl in constant prices of the year 2005 (to make the data more realistic the price index of sold production in manufacturing was used) for i-of this manufacturing division in t-period. The other symbols are the same as in the value added model.

The estimate results of the sold production model, where the variable explaining innovation activity of manufacturing are expenditures on R&D are included in table 7.

Table 7. Estimate results of parameters of one-factor models describing sold production value in manufacturing (LnPs) – model 1

Variable	Co-efficient	*t*	*p*	Co-efficient	*t*	*p*
	model (1.3.a)			Model (1.3.b)		
LnZatr	0,490	6,077	0,0000	0,471	6,132	0,0000
lnNinw	0,117	3,701	0,0003	0,117	3,728	0,0003
LnB+R	-0,132	-0,792	0,4293	-	-	-
t	0,639	18356	0,0000	0,638	18366	0,0000
Constant						
R^2	0,9797			0,9796		
Evaluation of group effects significance	LRT=327,090, p=0,0000; F=54,466, p=0,0000			LRT=327,606, p=0,0000; F= 55,027, p=0,0000		

Source: same as in table 4.

Observing the data in table 7 we notice that on the rational level of significance it is possible to find a statistically impact of R&D expenditures on the sold production value of manufacturing and none of the introduced delays of the variable *LnB+R* caused a change in this range. The estimated flexibility of the sold production value considering the amount of employment and capital investment expenditures are positive and account for 0,490 and 0,171 respectively, which confirms greater flexibility of sold production of industry in relation to employment than expenditures on investments. The evaluation of the time variable shows the average annual increase in sold production of ca 6,4%. After removing the insignificant variable from the model the outcomes of parameter estimate were slightly changed. It is proper to notice that likewise in the case of the value added model, group effects are statistically significant. The best effects of production means usage correlating this time with the value of sale occurred again in the divisions: manufacture of coke refined oil products and fuels, manufacture of food products and beverages, manufacture of chemicals and chemical products and manufacture of motor vehicles, trailers and semi-trailers. The relatively weakest in manufacture of textile products.

The estimation outcomes of the other version of the sold production model where innovation activity of manufacturing divisions is described by expenditures on innovation activity are presented in table 8.

Table 8. Outcomes of parameters estimate of one-factor models describing the value of sold production in manufacturing (LnPs) – model 2

Variable	Co-efficient	*t*	*p*	Co-efficient	*t*	*p*
	model (2.4.a)			model (2.4.b)		
LnZatr	0,652	8,599	0,0000	0,653	8,621	0,0000
lnNinw	0,149	4,221	0,0000	0,156	4,794	0,0000
LnInnow	0,113	0,459	0,6468	-	-	-
t	0,537	15,591	0,0000	0,537	15,618	0,0000
Constant						
R^2	0,9837					
Evaluation of group effects significance	LRT=338,052, p=0,0000; F=37,016, p=0,0000			LRT=378,904, p=0,0000; F=47,204, p=0,0000		

Source: same as in table 4.

The analysis of estimation results entitles us to state that the size of employment and investment expenditures are positively and significantly in the statistical sense correlated with the value of sold production and that a one-percent increase of each of these two factors causes on average the increase in sold production of ca 0,652% and 0,149% respectively. Unfortunately, the impact of innovation activity on sold production did not turn out to be statistically significant which is proved by the high value of test probability (p=0,648). The value of parameter evaluation with the time variable shows the average annual increase in sold production in manufacturing enterprises of ca 5,4%. Similarly to previous models statistically significant are group effects, which shows considerable differentiation of sold production value in particular divisions and a different level of production means use. The withdrawal of the insignificant variable *LnInnow* from the model did not influence essentially on the model evaluation results.

8. Labour productivity model

Among characteristics of competitiveness of enterprises the labour productivity model is also often applied. For the present undertaken in the research attempts to build a model of labour productivity dynamic were unsuccessful. A probable cause of this problem may be the complicated nature of the phenomenon and lack of correlation between the studied expenditures and quantitavely expressed labour productivity. It is also difficult to choose an economically explicit and at the same time correct functional form describing labour productivity measured as a quotient of value added and the size of employment in manufacturing divisions. Maybe labour productivity should be characterized by another measure. In labour productivity modelling also other descriptive variables should be taken into account including the variable describing economic situation on the market in the researched period. It is, however, a complex issue ambiguously described in the theory of economics. Modelling of labour productivity is a complicated issue and requires further analyses which the author will take up in the future.

9. Conclusion

It results from the conducted analyses that in the years 1999-2008 both positive and negative phenomena appeared in Polish manufacturing. In the researched period in real terms, unfortunately, there was a decline in expenditures on research and development activity on average per year of 3%. Luckily expenditures on research and development were characterized by a positive average annual rate of increase accounting for 1,4%. In particular manufacturing divisions the level of expenditures on development was very diverse. The divisions that were characterized by a large share of expenditures on R&D and innovation in the total amount expended by manufacturing enterprises are: manufacture of motor vehicles, trailers and semi-trailers, manufacture of food products, manufacture of chemicals and chemical products.

In the researched decade positive development tendencies were noticed in the manufacturing section (total), namely the average annual growth of gross value added (3,7%), labour productivity (4,1%) and the value of sold production (7%). Dynamic of the above competitiveness indices was very variable both in time and in manufacturing divisions. The highest positive rate of growth of all the three indices was noted in 2004, which is probably a result of earlier, long-term and expensive adjustments of manufacturing enterprises to standards of the EU. Two divisions, manufacture of coke, refined petroleum products and manufacture of motor vehicles, trailers and semi-trailers stand out in terms of high dynamic of growth of all the three competitiveness indices, namely labour productivity, gross value added and sold production.

In the conducted research we succeeded in building the models of gross value added and of sold production value in manufacturing divisions which were used to describe and access competitiveness of manufacturing in Poland. The application of Cobb-Douglas function of production facilitates interpretation of parameters in categories of flexibility of production indices in respect of outlays of particular productive factors. The conducted researches did not reveal a statistically significant impact of innovation activity (expenditures on R&D or expenditures on innovation) on value added and sold production value. There must be many causes of the lack of relations between these variables. The main reason may be too low value of the funding for development in order to find the existence of any correlation. Another cause may be that the sample comprising ten years prevents from testing this relation in the long term.

Unfortunately, we failed in our attempt to build a proper in the statistic and economic sense model of labour productivity. It is difficult, however, to believe there is no impact of innovation on labour productivity in manufacturing enterprises. Therefore, the cause of failure connected with modelling of labour productivity is not lack of relations between expenditures and labour productivity, but probably a low level of these expenditures, the sample comprising a too short span of time and lack of suitable research method.

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Streszczenie

AKTYWNOŚĆ INNOWACYJNA A KONKURENCYJNOŚĆ DZIAŁÓW PRZETWÓRSTWA PRZEMYSŁOWEGO W POLSCE

Nasilające się procesy globalizacyjne i integracyjne w gospodarce światowej, dynamiczne zmiany rynkowe oraz rosnące wymagania społeczne powodują, że poszczególne sekcje i działy gospodarki oraz przedsiębiorstwa w nich funkcjonujące, stają się coraz częściej uczestnikami walki konkurencyjnej.

Zdaniem M. Portera uzyskanie przewagi konkurencyjnej jest możliwe tylko poprzez działania innowacyjne, a zdolność przemysłu do innowacji i do podnoszenia poziomu technologicznego decyduje o konkurencyjności całej gospodarki. Dlatego we współczesnych badaniach ekonomicznych tak ważnym zagadnieniem jest określenie powiązań pomiędzy konkurencyjnością a działalnością innowacyjną przedsiębiorstw.

Celem artykułu jest próba ilościowego opisu wpływu nakładów na badania i rozwój oraz nakładów na innowacje na trzy wybrane charakterystyki określające konkurencyjność przedsiębiorstw przetwórstwa przemysłowego. Charakterystykami tymi są: wartość dodana brutto, produkcja sprzedana i wydajność pracy.

W badaniu wykorzystano publikowane dane statystyczne Głównego Urzędu Statystycznego o wysokości poszczególnych typów nakładów w podziale na poszczególne działy przetwórstwa przemysłowego (sekcja D PKD) w latach 1999-2008. Analiza została przeprowadzona z wykorzystaniem modeli panelowych, gdzie podstawowym okresem jest rok kalendarzowy, zaś obiektami są działy przetwórstwa przemysłowego na dwucyfrowym poziomie agregacji.