*Jan Zwolak* [*]

JEL Classification: D82, E22, L11, Q 55
Article review
https://doi.org/10.32910/ep.70.5.5

# STRUCTURAL CHANGES IN INNOVATION IN POLISH INDUSTRY

*As regards the relationship between changes in the structure of innovative marketed production and the structure of innovation expenditure, the efficiency of generating direct physical production capital and social capital in Polish industry has a decisive role. Since the rate (pace) of growth in innovative marketed production and the rate (pace) of growth in physical capital are determined by the milieu of a particular enterprise and are not dependent on enterprises, the only variable explaining the rate of innovation growth is the rate (pace) of growth (in the value) of expenditure on human capital in Polish industry in 2005–2013. The results of the survey show that the rate (pace) of growth (in the value) of expenditure on human capital was executed most extensively in Polish industry in 2010–2013, whereas in 2006–2009 this rate (pace) was shaped to a limited extent. As there was no uniform flow of expenditure on human capital, the total value of innovations created in Polish industry in the years analysed was limited.*

*Keywords: innovation structure, innovation rate, industry, Poland.*

[*] J. Zwolak, Ph.D., Full Professor, Faculty of Economics and Legal Sciences, Kazimierz Pulaski University of Technology and Humanities in Radom, Poland (e-mail: j.zwolak@uthrad.pl).

The paper was received on July 17th, 2018. It was accepted for publication on November 28th, 2018.

## 1. Introduction

Transformations in the economic structure of industry are the result of changes in revenues from the sales of new and significantly improved products. Long-term development co-exists with short-term safety and investment. Coordination of these elements causes crucial changes in the improvement of the systems and their integration into the local landscape (Frost, 2000). The demand that drives the revenues mentioned above is strongly responsive to external pressure. Trade liberalisation, in turn, brings about quite sustainable growth as well as productivity increase (Winters, 2004). Thus, the main source of structural transformations in industrial enterprises is innovative activity, including new technologies, aimed at placing on the market new and significantly improved products enabling a cost and competitive advantage on the market. Competition leads to an increase in employment and its re-assignment. A direct mechanism increases the transfer of qualified labour (Warzynski, 2003). The effects of a competitive advantage vary considerably depending on the industry sector. Resulting from Cameron and Chamal's studies (2004), the sets of enterprise managers ready to expand their programmes towards making a change and those ready to achieve their objectives were highly correlated. This indicates the unity of change and business objectives. With the elasticity of demand for a particular product, a reduction of its costs usually leads to the expansion of this industry. A cost advantage in another sector of industry may, in turn, bring about a shift of demand to this industry and the growth of other industries.

The determinants of the pace of structural changes in industry are interrelated and interdependent. Therefore, solving the problem of structural changes in innovation calls for determining the mutual relation between the basic determinants of innovation efficiency in industry.

As regards innovation research, the literature that points to the ways in which sustainable pace of increase in individual aspects of innovation impact or influence the new innovative output sold is unsatisfactory. The issue in question is very important because of implementations of top-efficiency innovations. The research discussed in this article indicates how differentiated paces of increase in aspects of innovation may imply decreased sales of new products whilst also decreasing the efficiency of innovation. The proposed research seeks to fill this gap, at least to a certain degree.

The objective of the survey is to identify the structure of innovative marketed production and the structure of the related innovation expenditure in Polish industry in 2005–2013. In addition, its aim is to identify the rates (pace) of growth in products and in innovation expenditure in Polish industry in the years analysed.

Hypothesis: the intended impact on the structure of new and significantly improved products is possible through an appropriate pace and structure of innovation expenditure, combining the structural-quality effect with the technological and technical effects in Polish industry.

## 2. Literature review

Most countries consider modern innovative industry to be one of the most poignant sectors of the economy. According to reference literature, the owners of industrial enterprises implement innovations for building further systems, innovative products and projects (Seaden & Manseau, 2001). Governments identify this issue as a very slow growth rate of investment in research and development (Dulaimi et al., 2002). The endogenous growth (Romer, 1986, 1990; Lucas, 1988; Krugman, 1991) is conditioned by an excess amount of knowledge from the outside, which constitutes an important source of innovation (Csugány, 2018). These external sources mould the specific region, engendering its faster growth rate.

The interplay between disciplines, suppliers and consumers causes the dynamics of innovation to be full of interaction, thus making it also more open (Hronszky & Kovacs, 2013). In an environment of globalisation, H. Chesbrough (2003) coined a new term for this new phenomenon: namely, free space innovation. Unavoidable costs of alternative research and development activities are incurred, together with their unimplemented innovative ideas and development alternatives in the form of additional income (Hronszky & Kovacs, 2013). The latter authors indicate that the costs, similarly to the risks of research and development, grow rapidly over time along the value chain as it becomes shorter and shorter. With the growth in innovation dynamics, they bring about high risk, also resulting in the high profit of the undertaking. The phenomenon of open innovation achieved through a new combined mechanism of research innovation allows us to understand the application of R&D in the innovation chain for the dynamic balancing of the innovation (qualitative and structural innovation changes). It is associated with an increase in the utility needs of customers (Mulder & Stappers, 2009), and it leads to further expansion of the structure of the innovation growth for each innovation (innovation restructuring).

The average high-tech sector and the real intensity of technology with a high proportion of R&D are characterised by the fastest growth rate of labour productivity (Lexa & Rojieek, 2007). The predominant grounds for shifting companies towards cost-orientation, which allows them to reduce labour costs, are as follows: market orientation (new markets), a qualified workforce, suppliers and mineral re-

sources (Ženka, 2009). On the other hand, the impact of globalisation on the factor resources (capital liquidity, free goods) and economic conditions (global competition intensity, the development of production factor costs, R&D, technology and organisation trends). These are both internal and external factors (Tiggeloove & Vossen, 2005; Pennings & Sleuwaegen, 2000). Some of the most important external factors also include relationships with suppliers (these are relational resources), dissemination of innovation and the dependencies on the research and development in the industrial sector (Breschi & Lissoni, 2001; Božić, 2011).

High main outlays increase the share of costs locked-in on tangible property (Stam, 2006). Investments in buildings and structures purchase of machinery and equipment or employee training are examples of costs which are difficult to recover. Most frequently, they become the trigger factor for dislocation of production activities – since costs vary from country to country (Tiggeloove & Vossen, 2005). Structural impact reaches the region, with relatively high intensity and productivity of capital output, which is the result of long-term specialisation in heavy industry.

Metropolises and regional centres are internally diversified in terms of stability to a significant extent. Their individual groups are also internally diverse. Moreover, they are located in major industrial cities which make for attractive technology centres. Furthermore, it must be noted that companies specialising in the automotive sector have a significant impact on the structural changes in urban districts and development centres. Important industrial R&D centres are located in these neighbourhoods (Ženka, 2009).

The selected reference literature allows for a revision of the effect of open innovation strategies on the innovation capacity in industry and its impact on the market. It is, therefore, necessary to review the changes in innovation efficiency in the industrial sector (Sarkar & Costa, 2008).

## 3. Methodology

The share of the component in the total in the reference period is marked as $y_{t-1}$, whereas the share of the component in the current period is marked as $y_t$, while the values $y_{t-1}$ and $y_t$ have a common measure.

As above, $y_{t-1}$ specifies the level of the phenomenon in time t-1, which is the basis of the comparison for the level of phenomenon $y_t$, in subsequent points in time as the indicators (indices) of the value $y_t$ dynamics:

$$\frac{i_t}{t-1} = \frac{y_t}{y_{t-1}} \tag{1}$$

The level of the phenomenon examined in the scheduled point in time t-1 is the basis for the comparison for the phenomenon $y_t$ level in subsequent points in time. If the basis is always the preceding point in time t-1, the indicators (indices) of dynamics are called chain indicators, and if the basis of the comparison is constant $y_{t-1}$, the indicators of dynamics are one-base indicators.

Thus, the value of the total increases, resulting from the changes in the share of particular elements in the total – up to the figures in the formula numerator (1). The changes in the share of particular components in the total depend on the intensity of changes in the range of the components and on the differences in the growth rates of the range of these components. Thus, the structural changes are the outcome of the uneven intensity of changes in the range of separate components.

There exist some relationships between the rates of growth in separate components in the total and the rate of growth in the share of these components in the total. However, it must be observed that there is no form of relationship between absolute increases of component shares in the total.

The rates of growth in particular component shares in the total and the rate of growth in the range of the whole group may be used to determine the rate of growth in the range of particular components of this total as: $\boldsymbol{i_m = i_t * i_m}$ where $i_m$ – rate of growth in the range of a specific component of the group, $\boldsymbol{i_t}$ – rate of growth in the share of a specific component of the group, $I_m$ – rate of growth in the range of the whole group.

The rate of growth in the range of the whole group ($I_m$) (2) may be calculated on the basis of the rate of growth in the share of a specific component of this group ($i_m$) and the rate of growth in the range of this specific component of the group:

$$I_m = \frac{i_m}{i_t} \tag{2}$$

Relative coefficients, which are general structural change indicators enabling the possibility of assessing the uniformity of changes in components of the total, are more useful in examining structural changes. The uniformity of changes in the elements of the total is, in turn, characterised by the proportionality of the development of particular components of the total. However, coefficients of relative structural changes may be used to characterise in time the proportionality of the development of relationships and proportions between components of the total. Relationships or proportions are strictly defined, in quantity terms, relations between components in the total. However, they do not characterise these relations qualitatively.

The examination of technical progress and innovation is connected with methodology selection, in particular the duration of events, processes and economic phenomena in time in the economy. In studies on technical progress and

innovation processes, the duration of the time horizon of the analysis performed is crucial (Pianta, 2001). The long-term approach requires that we accept assumptions which might result from the properties of the Cobb–Douglas function.

The technical progress rate comprising innovative processes has a parameter nature, and thus it has a determined; however, not specific value constant in time. In the Cobb–Douglas production function (Y), it may be taken into account as a mathematical constant:

$$Y = aX_1^b X_2^c e^{dt} \tag{3}$$

Where: $\boldsymbol{X}_1$ – labour input,

$\boldsymbol{X}_2$ – physical capital (asset) input,

$e$ – mathematical constant (technical progress rate),

$a, b, c, d$ – constant function parameters,

$t$ – time.

Following the relevant transformations of the function equation (3), the product growth rate ($y$) may be defined as the total of the appropriately weighted rates of growth in labour input ($\boldsymbol{x}_1$), physical capital ($\boldsymbol{x}_2$) and the rate of technical progress (innovation) ($d$) in time $t$ (4). It was proved that the productivity of the labour force is directly proportionate to the benefits from education productivity. The literature emphasises the importance of social capital (Temple, 2001/II). Human and physical capital are complementary factors, not substitution ones, like physical capital and raw labour force. Fixed asset (property) development is the source of labour productivity increase.

$$y = bx_1 + cx_2 + d \tag{4}$$

Then innovation growth rate ($d$) (5):

$$d = y - bx_1 - cx_2 \tag{5}$$

where: $d$ – innovation growth rate,

$\boldsymbol{x}_1$ – rate of growth in expenditure on human capital,

$y$ – product growth rate (constant),

$\boldsymbol{x}_2$ – rate of growth in physical capital expenditure (constant),

$b, c,$ – constant function parameters.

The innovation growth rate (5) is the surplus of the product growth rate above the total of the rates of human and physical capital (asset) expenditure.

## 4. Structure of marketed production and the related innovation expenditure

It has been determined that relationship exists between economic structures such as the structure of marketed production of new and significantly improved products and the structure of innovation expenditure. The relations between research development and innovation are comprehensive, non-linear. New goods, services, final products of higher quality as well as new production processes are created (Guellec & van Pottelsberghe de la Potterie, 2001).

*Table 1:*

MARKETED PRODUCTION OF NEW AND SIGNIFICANTLY IMPROVED PRODUCTS AND THE RELATED INNOVATION EXPENDITURE IN INDUSTRIAL ENTERPRISES IN POLAND, 2005–2013 (FIXED PRICES 2005)PLN MILLION

| Year | Marketed production of products: | | | Expenditure on product and process innovation: | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | total | new | improved | total | Research and development | Know-how from external sources and software | Buildings, structures and land | Machines, technical equipment and tools and means of transport | Training and marketing |
| 2005 | 148551.7 | 66848.3 | 81703.4 | 14237.1 | 1410.1 | 351.3 | 8597.5 | 3540.1 | 338.1 |
| 2006 | 128398.4 | 58036.1 | 70362.3 | 16187.6 | 1544.9 | 343.9 | 9924.3 | 3851.8 | 522.7 |
| 2007 | 122392.5 | 76838.0 | 45554.5 | 19177.4 | 1608.4 | 331.7 | 11721.4 | 4828.2 | 687.7 |
| 2008 | 125939.8 | 87276.3 | 38663.5 | 21014.0 | 1773.9 | 235.5 | 12340.1 | 5925.6 | 738.9 |
| 2009 | 104253.1 | 40658.7 | 63594.4 | 19633.0 | 2387.0 | 252.0 | 4877.4 | 11730.6 | 386.0 |
| 2010 | 123740.0 | 77708.7 | 46031.3 | 19049.2 | 2899.0 | 824.9 | 4210.4 | 10630.3 | 484.6 |
| 2011 | 114156.2 | 66667.2 | 47489.0 | 20814.6 | 3622.3 | 570.1 | 3481.0 | 12544.1 | 597.2 |
| 2012 | 116943.5 | 48414.6 | 68528.9 | 20828.9 | 3624.8 | 570.5 | 3483.4 | 12552.7 | 597.6 |
| 2013 | 112390.0 | 36729.1 | 75660.9 | 21668.9 | 4299.2 | 609.3 | 4465.4 | 11510.8 | 784.1 |

*Source:* Industry Statistical Yearbook 2006-2014. Polish Central Statistical Office, Warsaw, Poland. Authors' own calculations.

The methods applied to assess the structure of the marketed production of new and significantly improved products and the structure of innovation expenditure are based on the balance type of reasoning. Balancing, *input – output* analysis may be successfully supplemented by the evaluation of functional relationships be-

tween the technical progress and innovation rate and the structure of the marketed production. Production must be adapted not only in the calculation but also in reality; also the most important types of material input (Vanecek & Kalab, 2005). The selection of development priorities and the allocation of resource factors should be assessed from this particular perspective.

Based on the data in Table 1, it might be concluded that in 2005 each PLN 1 of innovation expenditure generated more than PLN 10 of the value of the marketed production of new and significantly improved products, whereas in 2013 it was only in excess of PLN 5. Thus, in the years analysed the value of the marketed production halved for each PLN 1 of innovation expenditure.

Structural changes in the marketed production and innovation expenditure are the outcome of the uneven intensity of the changes in the range of its components. Table 2 shows these changes versus the reference year.

*Table 2:*

DYNAMICS OF MARKETED PRODUCTION OF NEW AND SIGNIFICANTLY IMPROVED PRODUCTS AND THE RELATED INNOVATION EXPENDITURE IN INDUSTRIAL ENTERPRISES IN POLAND, 2005–2013 (2005 = 100) %

| Year | Marketed production of products: | | | Expenditure on product and process innovation: | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | total | new | improved | total | Research and development | Know-how from external sources and software | Buildings, structures and land | Machines, technical equipment and tools and means of transport | Training and marketing |
| 2005 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2006 | 86.4 | 86.8 | 86.1 | 113.7 | 109.6 | 97.9 | 115.4 | 108.8 | 154.6 |
| 2007 | 82.4 | 114.9 | 55.8 | 134.7 | 114.1 | 94.4 | 136.3 | 136.4 | 203.4 |
| 2008 | 84.8 | 130.6 | 47.3 | 147.6 | 125.8 | 67.0 | 143.5 | 167.4 | 218.5 |
| 2009 | 70.2 | 60.8 | 77.8 | 137.9 | 169.3 | 71.7 | 56.7 | 331.4 | 114.2 |
| 2010 | 83.3 | 116.2 | 56.3 | 133.8 | 205.6 | 234.8 | 49.0 | 300.3 | 143.3 |
| 2011 | 76.8 | 99.7 | 58.1 | 146.2 | 256.9 | 162.3 | 40.5 | 354.3 | 176.6 |
| 2012 | 78.7 | 72.4 | 83.9 | 146.3 | 257.1 | 162.4 | 40.5 | 354.6 | 176.8 |
| 2013 | 75.7 | 54.9 | 92.6 | 152.2 | 304.9 | 173.5 | 51.9 | 325.2 | 231.9 |

*Source:* Table 1 data inputs. Authors' own calculations.

Based on the comparison of the changes in the marketed production of innovative products and their innovation expenditure shown in Table 2, it may be concluded that the marketed production in the period analysed fell by over 24 percentage points, whereas innovation expenditure went up by over 52 percentage points.

As regards the marketed production of new products, changes which took place were of diverse nature, whiles regards the significantly improved products, a downward trend was observed until 2008 (financial crisis in the US). In 2009–2013, an upward trend was identified in the form of economic recovery. Another economic recovery (Francois & Lloyd – Ellis, 2003). In the period analysed, expenditure on research and development, as well as machines, technical equipment, tools and means of transport increased more than threefold. Expenditure on training and marketing in Polish industry grew threefold in 2005–2013. However, expenditure on know-how from external sources and software fell, whereas that on buildings, structures and land went up in 2005–2008. Reversed changes in that expenditure were observed in 2009–2013. The changes in the marketed production of new and significantly improved products and the related innovation expenditure show an increasing link between the expenditure on research and development (more than threefold) and the step changes in the value of the marketed production of new products in the period examined. It is worthwhile to add that expenditure on machines, technical equipment, tools and means of transport, as well as expenditure on know-how from external sources and software represent a passive transfer of technology and are a characteristic feature of Polish economic conditions.

*Table 3:*

DYNAMICS OF MARKETED PRODUCTION OF NEW AND SIGNIFICANTLY IMPROVED PRODUCTS AND THE RELATED INNOVATION EXPENDITURE IN INDUSTRIAL ENTERPRISES IN POLAND, 2006–2013 (PREVIOUS YEAR = 100) %

| Year | Marketed production of products: | | | Expenditure on product and process innovation: | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | total | new | improved | total | Research and development | Know-how from external sources and software | Buildings, structures and land | Machines, technical equipment and tools and means of transport | Training and marketing |
| 2006 | 86.4 | 86.8 | 86.1 | 113.7 | 109.6 | 97.9 | 115.4 | 108.8 | 154.6 |
| 2007 | 95.3 | 132.4 | 64.7 | 118.5 | 104.1 | 96.5 | 118.1 | 125.3 | 131.6 |
| 2008 | 102.9 | 113.6 | 84.9 | 109.6 | 110.3 | 71.0 | 105.3 | 122.7 | 107.4 |
| 2009 | 82.8 | 46.6 | 164.5 | 93.4 | 134.6 | 107.0 | 39.5 | 198.0 | 52.2 |
| 2010 | 118.7 | 191.1 | 72.4 | 97.0 | 121.4 | 327.3 | 86.3 | 90.6 | 125.6 |
| 2011 | 92.3 | 85.8 | 103.2 | 109.3 | 124.9 | 69.1 | 82.7 | 118.0 | 123.2 |
| 2012 | 102.4 | 72.6 | 144.3 | 100.1 | 100.1 | 100.1 | 100.1 | 100.1 | 100.1 |
| 2013 | 96.1 | 75.9 | 110.4 | 104.0 | 118.6 | 106.8 | 128.2 | 91.7 | 131.2 |

*Source:* Table 1 data inputs. Authors' own calculations.

Data in Table 3 show the indicators of dynamics with a variable basis which express chain connections between the events (phenomena) in the period examined. It should also be added that the events in the sequences analysed display a tendency of mutual correlation. Subsequent observations in time sequences show a trend of mutual correlation (Aczel, 1993). The rate of growth in the total marketed production value of new and significantly improved products is negative in most of the years examined, except for three or four in the case of significantly improved products points in time. However, the rate of growth in expenditure on total innovation over the whole period under examination is positive, excluding 2009 and 2010. Within expenditure on innovation, research and development is characterised by a positive growth rate over the whole period under examination. Expenditure on training and marketing is in second place, with a positive growth rate except for 2009 (when Poland was hit by the crisis). Within expenditure on innovation, machines, technical equipment and tools, as well as means of transport are characterised by the lowest number of years in which a negative growth rate was noted (2010 and 2013). Innovation expenditure characterised by the highest number of years with a negative growth rate was incurred on buildings, structures and land (2009, 2010 and 2011), as well as know-how from external sources and software (2006, 2007, 2008 and 2011).

The basis for identifying the sub-periods of the survey in the time sequence is the financial crisis in the US in 2008, which hit Poland in 2009. The absolute increases presented above provide information on absolute changes in the economic phenomenon level over time, whereas relative increases (Table 3) are the basis for determining the average annual rate of growth (change) as a parameter of the average phenomenon level assessment (Table 4).

The data in Table 4 indicate that over the period of 2006–2009 the average annual growth rate in the total marketed production of new and significantly improved products was negative. This determined a negative growth rate in the marketed production in 2006–2013. As regards the value of the marketed production, the most rapid growth rate was noted in the case of significantly improved products over the period of 2010–2013 (4.4%). The growth rate in the total marketed production was nearly 67% slower, and that of new products was negative in 2010–2013. Total expenditure on innovative products and processes in Polish industry in the whole period under examination was characterised by a positive growth rate (5.4%). The most rapid rate of growth in total innovation expenditure was observed in 2006–2009 (8.4%), whereas the slowest was in 2010–2013 (2.5%). This was the period immediately following the economic crisis. Expenditure on know-how from external sources and software was characterised by the most rapid rate of growth in 2010–2013 (25%). In the same sub-period, the rate of growth in expenditure on training and marketing was a little slower (19%). Out of innovation expenditure on assets, the most rapid growth rate was observed in respect of machines, technical equipment and tools,

and well as means of transport in 2006–2009 (35%). Throughout the whole period under examination and in the sub-periods, the rate of growth in expenditure on research and development was relatively stable (15%). However, this rate was too slow as compared to the rate of growth in the value of new products and types of mobile innovation expenditure on assets in 2006–2009 and throughout the whole period analysed. The remaining innovation expenditure was characterised by the slowest growth rate. That complicated the economic efficiency of the structure of innovation expenditure in Polish industry in the years examined.

*Table 4:*

AVERAGE ANNUAL RATE OF GROWTH IN THE MARKETED PRODUCTION OF NEW AND SIGNIFICANTLY IMPROVED PRODUCTS IN INDUSTRIAL ENTERPRISES IN POLAND, 2006–2013, %

| Specification | Years 2006–2009 | Years 2010–2013 | Years 2006–2013 |
|---|---|---|---|
| Marketed production of goods: | | | |
| - total | -8.5 | 1.9 | -3.4 |
| - new | -11.7 | -2.5 | -7.2 |
| - improved. | -6.1 | 4.4 | -1.0 |
| Expenditure on product and process | | | |
| innovation: | 8.4 | 2.5 | 5.4 |
| - total | 14.1 | 15.8 | 15.0 |
| - research and development | -8.0 | 24.7 | 7.1 |
| - know-how from external sources | -13.2 | -2.2 | -7.9 |
| and software | 34.9 | -0.5 | 15.9 |
| - buildings, structures and land | 3.4 | 19.4 | 11.1 |
| - machines, technical equipment | | | |
| and tools and | | | |
| means of transport | | | |
| - training and marketing | | | |

*Source:* Table 3 data inputs. Geometric mean. Authors' own calculations.

The innovation growth rate in the sub-periods, as well as throughout the whole period under examination was negative. This results from the fact that the rate (pace) of growth in the value of the total marketed production of new and significantly improved products was the slowest or negative. This does not permit the obtaining of a surplus above the growth rate of the product of the total rates (pace) of expenditure on human capital and physical capital (assets) in Polish industry in the years examined.

The diversity in the average annual growth rate brought about chaotic changes both in innovation expenditure on human capital and physical capital (assets) in Polish industry in the years examined. This was reflected in the structure of the marketed production and the related innovation expenditure as shown in Table 5.

Data in Table 5 show average changes in the structure of the value of the marketed production and the related innovation expenditure on human capital and physical capital (assets) in Polish industry in the years examined. They reflect the transformations in the system of elements and in the nature of changes in the period under examination. The analysis of the nature of growth in the sub-periods leads to the quantification of change trends in the marketed production and the related innovation expenditure. In 2005–2008, the share of new products in the structure of marketed production increased (by 24 percentage points), whereas in 2009 it declined (39%). In 2010, an increase in the share of this production was observed (62.8%), with a gradual reduction of its share in 2010–2013. However, it must be noted that this reduction does not respond in any way to an increase in the share of expenditure on research and development in 2009–2013 (by 7.6 percentage points), or to an increase in the share of machines, technical equipment and tools, and well as means of transport in the structure in 2009–2013 (approx. 60%).

*Table 5:*

STRUCTURE OF MARKETED PRODUCTION OF NEW AND IMPROVED PRODUCTS AND THE RELATED INNOVATION EXPENDITURE IN INDUSTRIAL ENTERPRISES IN POLAND IN 2005–2013, %

| Year | Marketed production of products: | | | Expenditure on product and process innovation: | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | total | new | improved | total | Research and development | Know-how from external sources and software | Buildings, structures and land | Machines, technical equipment and tools and means of transport | Training and marketing |
| 2005 | 100.0 | 45.0 | 55.0 | 100.0 | 9.9 | 2.5 | 60.4 | 24.9 | 2.4 |
| 2006 | 100.0 | 45.2 | 54.8 | 100.0 | 9.5 | 2.1 | 61.3 | 23.8 | 3.2 |
| 2007 | 100.0 | 62.8 | 37.2 | 100.0 | 8.4 | 1.7 | 61.1 | 25.2 | 3.6 |
| 2008 | 100.0 | 69.3 | 30.7 | 100.0 | 8.4 | 1.1 | 58.7 | 28.2 | 3.5 |
| 2009 | 100.0 | 39.0 | 61.0 | 100.0 | 12.2 | 1.3 | 24.8 | 59.7 | 2.0 |
| 2010 | 100.0 | 62.8 | 37.2 | 100.0 | 15.2 | 4.3 | 22.1 | 55.8 | 2.5 |
| 2011 | 100.0 | 58.4 | 41.6 | 100.0 | 17.4 | 2.7 | 16.7 | 60.3 | 2.9 |
| 2012 | 100.0 | 41.4 | 58.6 | 100.0 | 17.4 | 2.7 | 16.7 | 60.3 | 2.9 |
| 2013 | 100.0 | 32.7 | 67.3 | 100.0 | 19.8 | 2.8 | 20.6 | 53.1 | 3.6 |

*Source:* Table 1 data inputs. Authors' own calculations.

Opposite trends emerge in the share of significantly improved products in the marketed production in Polish industry over the period under examination. In 2005–2008, a decline was observed, whereas in 2009–2013 there was an upward trend. In 2005, the share of the marketed production of new and significantly improved products is similar to one another, whereas in the last year analysed it changes to reach a ratio of 1:2.

Thus, it may be noted that the transformations in the structure of innovation expenditure were more favourable to an increase in the share of the marketed production of new and significantly improved products than to new ones. In the context of endogenous growth, surpluses required to maintain production emerge naturally as rewards for happy innovative activity (Francois & Roberts, 2003). Changes in innovation expenditure were as follows: doubling expenditure on research and development, doubling the share in the expenditure structure of machines, technical equipment and tools, and well as means of transport over the period under examination; and reducing threefold the share of innovation expenditure on buildings, structures and land. It is necessary to apply innovation in the development process in order to form intelligent expert systems (Lynch et al., 2000; Stojčić et al., 2018; Zekić, & Samaržija, 2017). In addition, the share in the expenditure structure of know-how from external sources and software, as well as training and marketing was maintained at a relatively similar low level.

## 5. Summary and conclusions

The following hypothesis was confirmed: the intended impact on the structure of new and significantly improved products is possible through an appropriate pace and structure of innovation expenditure, combining the structural-quality effect with the technological and technical effect in Polish industry.

An increase in the marketed production of new and significantly improved products may take place in time for numerous reasons, which may appear jointly or separately.

The group of reasons behind the factors analysed comprises the development of the technical and innovative know-how accompanied by relative stabilisation of the available factors of production.

The dynamic analysis may be carried out upon disaggregation of the reasons behind the innovative production increase due to an improvement of the technical and innovative know-how. It is justified to apply here numerous rates, as the direct effect of the technical progress and innovation is the change of the structure of all macro-dynamic variables examined in the survey.

Technical progress determines a constant change of not only the structure of marketed production, but also the structure of human and physical capital.

As regards the relationship between changes in the structure of innovative marketed production and the structure of innovation expenditure, of importance is the efficiency of directly generating physical production capital and social capital. Since the rate (pace) of growth in innovative marketed production of new and significantly improved products and the rate (pace) of growth in physical capital are determined by the milieu of a particular enterprise, and are not dependent on decisions of particular enterprises, the only variable that explains the rate of innovation growth as the endogenous and not exogenous variable (long-term analysis) is the rate (pace) of growth (in the value) of expenditure on human capital in Polish industry in 2005–2013.

Out of the years examined, the rate (pace) of growth (in the value) of expenditure on human capital was executed most extensively in Polish industry in 2010–2013. This is represented by the diverse rates of growth (in the value) of expenditure on research and development (16%), expenditure on know-how from external sources and software (25%), and expenditure on training and marketing (19%). Although these rates are rapid, they relate to a short span of years and are in disequilibrium. However, the preparation and creation of innovation, because of the long time horizon, are considered asinter-generation processes (15–20 years).

In 2006–2009, the rate (pace) of growth (in the value) of expenditure on human capital was executed to a limited extent through the rates of growth in expenditure on research and development (14%), and expenditure on training and marketing (3.4%). The remaining expenditure was characterised by a decline. In this sub-period, there was no parallel flow of expenditure on human capital, and thereby the total of the value of the innovation created was limited.

The result of creating the innovation growth rate is the rate (pace) of growth (in the value) of expenditure on human capital, although executed to a limited extent through the rates of growth in expenditure on research and development (15%), on know-how from external sources and software (7%), and expenditure on training and marketing (11%). The creation of innovation depends on the structure of human capital, which in the years analysed was stimulated by a disequilibrium of the growth rate in expenditure which constituted a non-uniform flow of expenditure on human capital in Polish industry. This proves the key importance of all dimensions of the innovation potential in order to exploit it effectively.

The average annual growth rate of total process and product innovation outlays, as compared with an average annual rate of total production sold of new and improved goods in Polish industry in the years 2006–2009, amounted to zero (was nullified), while between 2010–2013the growth rate of innovation expenditure was slightly faster than innovative production – by 0.6 percentage points, whereas in the years 2006–2013, the growth rate of innovation investment slowed down,

which contributed to a regression in the growth rate of production sold of new and significantly improved goods in Polish industry.

## References

Aczel, A. D. (1993). *Complete Business Statistics*, Second Edition, Irvin, Burr Ridge, Illinois, USA, 624.

Božić, L. J. (2011). Constraints to Innovation Activities in Croatian Enterprises. *Ekonomski Pregled,* 62 (3-4), 177-189.

Breschi, F., & Lissoni, S. (2001). *Knowledge Spillovers and Local Innovation Systems: A Critical Survey*. Presented at the European Regional Science Association Conference, Barcelona.

Cameron, D., & Chamala, S. A. (2004). Measuring impacts of on holistic farm business management training program. *Australian Journal of Experimental Agriculture*, 44 (96), 531-538. doi:10.1071/EA02058

Chesbrough, H. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press, Boston.

Csugány, J. (2018). Empirical evidence about differences in human resource conditions between innovation - and imitation-based economies.*Ekonomski Pregled*, 69 (5) 533-551.

Dulaimi, M. F., Ling, F.Y.Y., Ofori, G., & De Silva, N., (2002). Enhancing integration and innovation in construction. *Building Research and Information*, 30 (4), 237-247. doi:10.1080/09613210110115207

Francois, P., & Roberts, J. (2003). Contracting Productivity Growth. *Review of Economic Studies*, 70 (1), 59-85. doi: org/10.1111/1467-937X.00237

Francois, P., & Lloyd-Ellis, H. (2003). Animal Spirits through Creative Destruction. *The American Economic Review*, 93 (3), 530-550. doi: 10.1257/000282803322156972

Frost, F. M. (2000). Value orientations: impact and implications in the extension of complex farming systems, *Australian Journal of Experimental Agriculture*, 40 (4), 511-517. doi: 10.1071/EA99078

Guellec, D., & van Pottelsberghe de la Potterie, B. (2001). R&D and productivity growth: panel data analysis of 16 OECD countries. OECD Economic Studies, OECD Publishing, 2001 (2), 103-126. doi.org/10.1787/652870318341

Hronszky, I., & Kovács, K. (2013). Interactive Value Production Through Living Labs. *Acta Polytechnica Hungarica*, 10 (2), 89-108. doi: 10.12700/APH.10.02.2013.2.7

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99 (3), 483-499. doi:.org/10.1086/261763

Lexa, J., & Rojiéek, M. (2007). *Branch knowledge – intensity and Competitiveness of the Czech Economic*. Working Paper CES VŠEM: 10,80p.

Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22 (1), 3-42. doi.org/10.1016/0304-3932(88)90168-7

Lynch, T., Gregor, S., & Midmore, D. (2000). Intelligent support systems in agriculture: how can we do better ?. *Australian Journal of Experimental Agriculture*, 40 (4), 609-620.doi:org/10.1071/EA99082

Mulder, I. & Stappers, P. J. (2009). Co-Creating in Practice: Results and Challenges, Proceedings of the 15th International Conference on Concurrent Enterprising , ICE'2010 "Collaborative Innovation: Emerging Technologies, Environments and communities", Leiden , The Netherlands, June 2009

Pennings, E., Sleuwaegen, L., & Monmaerts, G. (2000). *Relocation, an Element of Industrial Dynamics*. Synthesis Report Brussels: Federal Planning Bureau.

Pianta, M. (2001). *Technology and the Future of European Employment*. Edited by Pascal Petit and Luc Soete. Edward Elgar, Cheltenham, UK, Northampton, MA USA, 143.

Romer, P. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94 (5), 1002-1037.

Romer, P. (1990). Endogenous technological change. *Journal of Political Economy*, 98 (5), S71--S102. doi: 10.3386/w3210

Sarkar, S., & Costa, A.J.A. (2008). Dynamics of open innovation in the food industry. *Trends in Food Science & Technology* 19, 574-580. doi: 10.1016/j. tifs.2008.09.006

Seaden, G., & Manseau, A. (2001). Public policy and construction innovation. *Building Research and Information*, 29 (3), 182-196. doi: 10.1080/09613210010027701

Stam, E. (2006). *Why Butterflies Don't Leave. Locational Evolution of Evolving Enterprise*. Discussion Paper No. 2006-20. Utrecht Max Planck Institute of Economics. Group for Entrepreneurship, Growth and Public Policy.

Stojčić, N., Hashi, I., & Aralica, Z. (2018). Creativity, innovations and firm performance in an emerging transition economy. *Ekonomski Pregled*, 69 (3), 203-228.

Temple, J. (2001/II). Growth effects education and social capital in the OECD countries. *OECD Economic Studies*, 33, 57.

Tiggeloove, N., & Vossen, M. (2005). *Vision on Relocation*. Research Paper No. 05BEB05. Hague: Ministry of Economic Affairs.

Warzynski, F. (2003). The causes and consequences of sector-level job flows in Poland. *Economics of Transition*, 11 (2), 357-381. doi.org/10.1111/1468-0351.00150

Winters, L.A. (2004). Trade Liberalization and Economic Performance: An Overview. *Economic Journal*, 114 (493), F4-F21. doi.org/10.1111/j.0013-0133.2004.00185.x

Vanecek, D. & Kalab, D. (2005). The material flow on agricultural farms, *Journal of Central European Agriculture*, 4 (2), 121-130.

Zekić, Z., & Samaržija, L. (2017). Analysis of the impact of selected supply chain management factors on the performance of wood industry clusters in the republic of Croatia. *Ekonomski Pregled*, 68 (1), 59-87.

Ženka, J. (2009). Delokalizace zpracovatelského prúmyslu ÉR – komponenti analýza. (Delocalization of Czech Manufacturing – Component Analysis). *Politická ekonomie,* 1, 77-91.

## STRUKTURNE PROMJENE U INOVACIJAMA U POLJSKOJ INDUSTRIJI

### Summary

U pogledu odnosa između promjena u strukturi inovativne tržišne proizvodnje i strukture izdataka za inovacije, učinkovitost stvaranja izravnog fizičkog proizvodnog kapitala i društvenog kapitala u poljskoj industriji ima presudnu ulogu. Budući da je stopa (tempo) rasta inovativne tržišne proizvodnje i stopa (tempa) rasta fizičkog kapitala određena okruženjem određenog poduzeća i nisu ovisna o poduzećima, jedina varijabla koja objašnjava stopu rasta inovacija je stopa (tempo) rasta (u vrijednosti) rashoda za ljudski kapital u poljskoj industriji u 2005–2013. Rezultati ankete pokazuju da je stopa (tempo) rasta u ljudskom kapitalu najintenzivnije ostvarena u poljskoj industriji u razdoblju 2010–2013, dok je u razdoblju 2006–2009. ova stopa (tempo) oblikovana u ograničenom opsegu. Kako nije postojao ujednačen protok ljudskog kapitala, ukupna vrijednost inovacija stvorenih u poljskoj industriji u analiziranim godinama bila je ograničena.

Ključne riječi: struktura inovacija, stopa inovacije, industrija, Poljska.