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DETERMINANTS OF R&D ACTIVITY – ANALYSIS OF THE POLISH LOGISTICS SECTOR

DOI: 10.26399/meip.3(62).2018.32/j.marszalek

INTRODUCTION

The logistics sector plays an important role in the development of any economy due to the nature of the business – spatial movement of resources. It provides a mechanism for efficient allocation of resources, which is the foundation of the market economy. In many instances the development of infrastructure necessary for the provision of logistics services determines the economic growth of the region. This is due to the greater availability of material resources and human capital. The intensity of this development also stimulates economic activities of logistics companies. While infrastructure changes have their roots in transport policy pursued by the state or region, the development of the logistics sector is also dependent on factors stimulating the development of entrepreneurship as such. This means that economic activity of logistics enterprises is the result of feedback between possibilities offered by their business and the degree of regional economic growth, although it is the development of infrastructure that triggers this dependence (Truskolaski 2006).

This article discusses the problem of R&D investment of logistics enterprises in Poland. The development of transport infrastructure, mainly road infrastructure, creates opportunities for the development of this sector, especially in the context of sustainable economic growth in Poland. However,

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investment activity of enterprises does not depend on the conditions of the broad economic environment, but it results from the competition in the immediate environment and the adopted development strategy of the entity. For this reason, potential determinants of investment of logistics companies were taken into account broken down by their origin: infrastructural and macroeconomic conditions, the intensity of competition in the sector and financial performance of enterprises. The aim of the article is to identify factors significantly affecting the level of R&D investment in logistics companies and to determine the strength of this impact.

Determinants of R&D of Logistics Companies

Investment decisions of logistics companies are based on premises similar to those followed by other private entities. Investment activity of an enterprise depends on three groups of determinants: demand, supply and state policy (Różański 2006). Demand-related conditions result from the market in which the entity operates and are connected with the level of competition within a given sector. Supply factors concern the costs of the business. State policy is an element affecting both supply and demand circumstances. This impact is all the greater, the stronger the sector is regulated by the state. This applies above all to creating conditions conducive to competition, as well as to implementing specific economic policy that stimulates the activity of entities, e.g. financing infrastructure from public funds.

The demand aspects of investment activities of Polish logistics companies are primarily related to the level of intra-sector competition (Rosa 2013). It is worth noting that the market of logistic services is highly fragmented (in 2009–2015 these companies employed on average 5 people) (Local Data Bank CSO 2017). This primarily affects the scope of their business operations and access to lending offers of banks to finance investment projects.

The size of enterprises also means that they focus mainly on the local market, which means that the local infrastructural conditions and local economic growth gain in importance. For this reason, the intensity of competition measured by the number of competitors was assumed as the first potential determinant of R&D expenditure and the first research hypothesis was formulated. As already noticed by Joseph Schumpeter, an acclaimed pioneer of research on the R&D activity of enterprises, while the fragmented market creates a market mechanism, enterprises have better conditions for conducting R&D activity on the more monopolised market (García-Quevedoa,

Pellegrinoa, and Vivarellic 2014). The size of enterprises also means that they focus mainly on the local market, which means that the local infrastructural conditions and local economic growth gain in importance. For this reason, the intensity of competition measured by the number of competitors was assumed as the first potential determinant of R&D expenditure and the first research hypothesis was formulated.

Hypothesis 1. The number of current and new competitors intensifies competition among enterprises, which increases their R&D activities, therefore, it is positively correlated with expenditures on development of logistics companies.

The local scope of business activities of logistics companies also facilitates the reduction of operating costs (Szymonik 2013). Competition takes on the features of the free market opening the way to almost any competitive strategy, which, in turn, determines investment policy of the company (Popiołek 2014). Companies that are best suited for competing will be able to generate operating surplus, which can be later used in development activities. Other companies, due to the lack of such an opportunity and difficult access to financing, will conduct less active development activities. The above considerations lead to the following second research hypothesis.

Hypothesis 2. Being able to achieve the operating margin target determines development activities because the higher the efficiency of operating activities (the lower the share of operating costs in operating revenues), the higher R&D expenditure of logistics companies.

Development investments engage capital – own and from external sources. An enterprise can pursue a safe financing policy based on its own resources, which means that investments are financed mainly from generated financial surpluses (Coad, and Rao 2010). The second solution is to apply an aggressive strategy based on the external capital, i.e. to incur debt. Such a strategy can be applied if the enterprise in question is sufficiently profitable at the operational level to guarantee proper debt servicing. Therefore, if we assume that R&D investments depend on operational efficiency, the latter should be accompanied by a more aggressive financing policy reflecting investing operators' ability to accept higher risk (Lev, and Sougiannis 1996).

However, many studies indicate that companies which invest intensively in R&D have relatively low debt levels (Hall 2002; Wang, and Thornhill 2010).

This is caused by their inability to secure debt. R&D activities often have very limited collateral value and companies usually have to use other assets to obtain debt financing (Berger, and Udell 1990). The second reason is that debt financing may lead to financial problems, which can be particularly severe in the case of R&D activity of the company (Cornell, and Shapiro 1988). Equity capital has many advantages over debt in financing research and development. Although the biggest disadvantage of equity financing seems to be the difficulty in its quick acquisition, in this article it was assumed that the behaviour of the surveyed enterprises is consistent with the pattern observed so far. Therefore, a conservative policy of R&D financing by logistics enterprises was adopted as it is the only way for a company to accumulate surplus necessary to finance the investment.

R&D investments are related to specific liquidity policy of the company. A higher level of indebtedness may reduce financial liquidity as enterprises liquidate excess liquidity with financing costs. This is partly due to the fact that the development process is not fully predictable and it may involve some additional investments in research, hiring specialists or the need to implement the results. In a competitive environment companies must act quickly. This forces developing companies to maintain a financial buffer in case of emergency costs (Brown, and Petersen 2011). For this purpose, they often maintain a high level of cash and a lower level of receivables, which may lead to higher liquidity levels (Bates, Kahle, and Stulz 2009). The availability of the capital market is a factor that may limit such behaviour (Opler et al. 1999). Studies of US companies involved in R&D projects have shown that they keep lower cash liquidity the greater their access to finance. So if a sudden investment expenditure must be incurred they can use several sources of capital at the same time, choose the most favourable or currently available one. External equity capital plays a particularly important role (Brown, Martinsson, and Petersen 2012). For companies examined in this article, access to capital is rather limited, therefore, a higher level of financial liquidity should be expected. Sometimes enterprises maintain a higher level of liquidity by changing the structure of assets. A positive relationship between disinvestments and the level of expenditure on R&D was observed (Borisova, and Brown 2013). These changes are accompanied by a significant increase in cash flow that increases the company's liquidity. In the group of the surveyed enterprises, such a source of financing of development activities may be used, however, due to the lack of data on changes in the fixed assets value, the research in this area was not carried out. It is worth noting that the results of a questionnaire survey of Polish transport companies, which make

up a major part of the logistics sector, carried out by EFL, confirmed the correlation between liquidity and investment outlays. However, the strength of this relationship was not specified (EFL 2014).

Hypothesis 3. Outlays of logistics companies on R&D are accompanied by higher profitability, lower debt levels and higher liquidity.

Barriers to access to capital concern mainly smaller and younger enterprises (Fishman, Rob 1999). This is due to limited resources, e.g. insufficient fixed assets, which can provide collateral for a debt (Dalziel, Gentry, and Bowerman 2011). In the case of logistics companies, whose fixed assets are often leased, this barrier is particularly important. A short business history and insufficient assets also impede equity raising. The company is unreliable to new potential owners. Larger enterprises are better prepared for R&D activities also due to their resources. Their experience allows better management of the development process (Tsai, and Wang 2004; Park, Jaeun, and Kim 2010).

Hypothesis 4. Limitations of smaller enterprises results in a positive relationship between R&D expenditure and the size of logistics companies.

Logistics companies have a lot in common with entities from other sectors, but they are much more dependent on state policy. Transportation, a vital element of the logistics industry, needs efficient infrastructure. The role of the state is fundamental here. The investment process that has been going on for many years has focused mainly on road infrastructure and seems to be an important factor affecting the development of logistics companies. The development of road infrastructure is also dependent on the degree of urbanisation of the area in question.This is most often connected with the rate of growth of a particular region, availability of skilful staff with university diplomas or the demand represented by other operators interested in the services of logistic companies. Under such conditions, logistics companies can develop. Previous studies indicate that under growing demand companies predominantly seek to grow and R&D activities are their second top priority. They are pursued primarily by adapting already existing solutions to better meet customers' requirements (Barge-Gil, and López 2014).

The development of logistics companies would be difficult without access to engineers and specialists, especially in the field of management (Galende, and Suarez 1999). Research results also suggest that the company's technical staff who

have knowledge of technological fields can integrate knowledge for research and development purposes (Fleming 2001). The presence of active academic centres may also contribute to the intensity of conducting and implementing R&D. This skill has been described in the absorptive capacity theory (Cohen, Levinthal 1990). Many studies confirm that it does exist (Barge-Gil, and López 2014).

For these reasons, the degree of urbanisation and access to infrastructure should support the logistics industry. The increase in the number of enterprises and competition between them can stimulate development activities. It is worth noting that strongly urbanised areas are mostly characterised by high GDP, which is a consequence of the number of business entities. The assessment of the relation between R&D expenditure and GDP allows the nature of competition between entities to be determined. Strong GDP growth may be 'consumed' by the growing number of enterprises and will not be conducive to competition if enterprises are satisfied with their current scope of activity. However, if R&D expenditure increases along with the increase in GDP, it will also mean increased competition within the sector.

Hypothesis 5. The degree of the urbanisation of the region measured with GDP per capita, the size of business population, and the availability of university graduates encourages R&D expenditure of logistics companies.

Since transportation nodes can develop outside of agglomerations, the inclusion of access to infrastructure regardless of the degree of urbanisation will allow for highlighting its impact on the development of logistics companies. On the one hand, the latter will depend on demand factors, but on the other hand, the essence of the industry is to transport resources. Therefore, the location of logistics operators, i.e. the location of their R&D investment, may be cost-driven, not necessarily related to the degree of urbanisation. Excessive concentration of state support in financing of road transport infrastructure seems to be an important factor limiting the development of other transport activities, especially rail transport (The Ministry of Infrastructure of the Republic of Poland 2011). There is no doubt that improved infrastructure, especially motorways, supports the development of the transport sector, although this is not necessarily connected with regional development. This is due to higher capital intensity of transport in conditions of less developed infrastructure (Krzemiński 2007:102).

Hypothesis 6. R&D expenditure of logistics companies depends on the availability of a system of roads measured by their length in the region where a particular company is based.

Verification of the above hypotheses will allow for identifying the determinants of R&D investment decisions of logistics companies in a multi-dimensional approach. The analysis will cover both the conditions of competition in the sector, the microeconomic financial situation of enterprises and their ability to invest. The whole study completes the assessment of general conditions determining the development of the sector of logistics companies.

Data and Research Method

To study R&D investment outlays of logistics companies we used data on Polish logistics companies available from the Local Data Bank of the Central Statistical Office of Poland [Polish abbr. GUS] for a group of transport companies (section H) for the period 2007–2015.

Table 1

Capital expenditures, operating revenues and the number of logistics companies in Poland in 2009–2015

	2009	2010	2011	2012	2013	2014	2015
R&D expenditure (in PLN million)	1,720.4	1,762.2	6,322.0	5,298.1	7,309.0	4,002.2	7,356.7
Number of enterprises	131,959	138,642	145,942	141,748	135,225	140,682	145,955
R&D expenditure per enterprise	0.013	0.013	0.043	0.037	0.054	0.028	0.050
Operating revenues per enterprise	0.559	0.579	0.606	0.671	0.711	0.716	0.724

Source: the author's calculations based on the Local Data Bank of the Central Statistical Office of Poland.

The analysis of values presented in Table 1 helps us notice that enterprises surveyed by the Central Statistical Office generally increased R&D expenditures. However, the exercise is not a continuous one. The nominal values of these investments sometimes decreased over the observed period. This occurred despite the increased number of enterprises and the growth of the entire sector, as evidenced by the growing value of average operating

revenues. The average value of R&D expenditures of logistics company did not increase. It can, therefore, be assumed that competition between enterprises did not force them to be active in R&D.

We distinguished the following three groups of potential development policy determinants for entities covered by the study: intensity of competition, financial performance of the company, and macroeconomic conditions. The first group, which specifies the number of enterprises in the sector: newly created (designated as X2.1.) and existing ones (designated as X2.2.), was taken as a measure of competition intensity. In the second group (designated as X3.1–X.3.14), selected items from financial statements and relations between them were taken into account in order to demonstrate microeconomic determinants of investment outlays. The following variables were included in the study: the share of production costs of products in revenue from operating activities, as a measure of the ability to achieve margin on core operations (X3.1); the share of variable costs in revenue from operating activities, as a measure of the operating leverage of the enterprise (X3.2); the relation of the financial result from sales to the net result, as a measure of the financial leverage of the enterprise (X3.3); the net turnover profitability ratio, defined as a relation of the net financial result to revenues from total activity (X3.4); financial liquidity ratio I, defined as a relation of current assets to current liabilities (X3.5); financial liquidity ratio III, understood as a relation of cash and its equivalents to current liabilities (X3.6); the net result to total loans ratio (X3.7); the business result to long-term liabilities ratio (X3.8); the result of economic activity to total loans ratio (X3.9); revenues from total activity (natural logarithm), as a measure of the size of the enterprise (X3.10); the relation of financial costs to the financial result of business activities, as a measure of the possibility of using leverage (X3.11); the share of the number of enterprises showing positive net profit in the total number of enterprises (X3.12); the value of bank loans and total loans taken out (natural logarithm) (X3.13); gross financial result burden – income tax (X3.14).

The third group includes the following macroeconomic and infrastructural factors understood as external incentives for the development of logistics companies: the value of GDP per capita (in current prices, as a measure of economic growth (X4.1); the number of university graduates, as a measure of the development potential of the region (X4.2); the total population of enterprises, as a measure of the potential demand for logistics services (X4.3); the length of motorways and expressways (X.4.4); the length of public roads, showing the degree of urbanisation of the region (X4.5).Statistical characteristics of the variables examined in the paper are presented in Table 2.

Table 2

Descriptive statistics of variables used in the study (national level) (n=9)

Variable	Arithmetic mean.	Median	Standard deviation	Kurtosis	Skewness
Y	4031.59	4002.20	2462.75	–2.02	0.17
X2.1	19017.13	19150.00	1238.79	–0.71	–0.26
X2.2	140021.86	140682.00	4834.24	–0.86	–0.35
X3.1	0.95	0.91	0.05	2.87	–1.32
X3.2	0.61	0.61	0.00	1.29	1.38
X3.4	1.22	1.20	0.10	4.53	1.82
X3.5	3.71	3.97	1.33	5.57	1.09
X3.6	0.33	0.37	0.49	–3.82	–0.10
X3.7	1.13	1.23	0.26	–1.55	–0.25
X3.8	2.14	2.11	0.50	–0.10	–0.15
X3.9	0.97	1.05	0.24	–1.79	–0.30
X3.10	21.38	21.44	0.16	–1.11	–0.51
X3.11	0.37	0.37	0.07	0.09	0.06
X3.12	80.25	79.65	2.37	–1.83	0.20
X3.13	18.23	16.25	4.27	–3.91	–1.11
X3.14	16.50	16.46	0.09	1.04	1.30
X4.1	39,505.44	40,669.00	1,079.08	0.04	0.60
X4.2	429,889.89	424,317.00	37,640.65	–0.35	0.04
X.4.3	3,936,974.00	3,909,802.00	185,419.56	–1.22	0.33
X.4.4	2,128.90	2,112.50	793.76	–1.91	–0.02
X4.5	405,292.16	412,149.40	14,781.66	–1.36	–0.79

Source: the author's calculations based on the Local Data Bank of the Central Statistical Office of Poland.

The analysis of descriptive statistics of aggregated variables at the national level presents a fairly diversified picture of the examined data. The observed variables exhibit low, as well as high volatility. The described variable exhibits

moderate volatility. The median is not significantly different from the arithmetic mean. However, kurtosis has a significantly negative value, which indicates the flattening of the distribution and an increase in the probability of different values. The low and positive skewness of the distribution indicates that values above the determined average are more likely.

Variables related to the concentration of logistics enterprises (X2.1, X2.2) are characterised by low variability as well. The value of arithmetic mean does not differ significantly from the median value. The value of kurtosis is also low, but negative, which indicates the flattening of the variable distribution and, consequently, a value different from the average. The distribution exhibits a left-sided asymmetry, which increases the probability of observations smaller than the average. In the group of variables which describe financial relations high volatility is observed in liquidity ratios (X3.5, X3.6), as well as in net turnover profitability (X3.4). In the first case, the distributions of variables are diametrically different. Observations of the liquidity index I have asymmetrical right-sided distribution with high positive kurtosis, which means that there are several cases significantly exceeding the average level. In turn, the liquidity index III is observed as a left-sided asymmetrical distribution with high negative kurtosis, which means the occurrence of cases significantly below the average level. The value of bank loans and total loans taken out is also very different (X3.13). Standard deviation has a high value and the values of kurtosis and skewness indicate flattened distribution with a left-sided asymmetry.

The smallest diversity of observations occurs in the business result to long-term liabilities ratio (X3.8), the relation of financial costs to the financial result of business activities, as a measure of the possibility of using leverage (X3.11) and the value of GDP per capita (X4.1). Other variables describing financial performance of the surveyed companies are moderately volatile. The arithmetic mean values are not significantly different from the median level. We observe a delicate asymmetry of both left-sided and right-sided distribution. Kurtosis is mostly close to zero or slightly negative, while even a more flattened distribution type is observed in the group of variables defining external development stimulants for logistics enterprises (X4.2–X4.5). In all cases negative kurtosis was observed. The variability of variables is low or moderate. As before, a delicate asymmetry of both left-sided and right-sided distribution is observed.

A statistical test was carried out on aggregated national values and using regional-level data. A descriptive statistics analysis of the variables at the voivodship (regional) level allows for drawing conclusions similar to those for

nationwide data, although the degree of diversification within each voivodship is slightly higher. Data for voivodships helped us determine the importance of local economic development for the investment policy of logistics companies. As a result, the study was more accurate. The assessment of dependence in this case is so difficult because the time series are very short, they cover only the years 2007–2015 (n = 9). Unfortunately, since GUS has changed the pattern of aggregating economic operators into groups within the Polish Classification of Economic Activities, it is not possible to acquire comparable data for earlier periods. The evaluation of relations between variables made for voivodships can be treated only as indicative and requires further analysis in subsequent years.

In order to precisely determine factors determining investment expenditures of enterprises from the logistics sector, a correlation study was conducted. The study was based on the Pearson correlation coefficient, which requires several assumptions to be met: (1) variables must be quantitative, (2) the relationship between them should be linear, and (3) two-dimensional distribution of the dependent variable should be normal (the larger the sample, the greater the resistance of the measure to deviations from the last assumption). When any of the above assumptions is not met, instead of the Pearson linear correlation coefficient the Spearman rank correlation coefficient is usually used. Considering the nature of the sample, and a large spread of values of the analysed variables, as well as deviations from the linearity of the relationship between them, in some cases – even though we study quantitative variables – Pearson's linear correlation coefficient should be given up in favour of Spearman's rank correlation coefficient. In the analysis, a correlation study with the use of both coefficients was conducted.

Large dispersion of values of the analysed variables also hinders the construction of an econometric model that would in a multidimensional manner allow for describing investment expenditures on research and development in the section of transport and storage companies in relation to their financial characteristics. Panel models, estimated on the basis of the cross-sectional test, prove to be useful in this case. In these models the intercept or random component is decomposed by objects and time units. In this case, a model with decomposition of the intercept (FEM – Fixed Effects Model) was used. In FEM m_i is decomposed into the intercept (fixed) for individual groups separately. The model takes the following form (Witkowski 2012: 267):

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

where: a_i – specific intercepts, and d_i – dummies, taking the value 1, when $j = i$, b – structural parameter expressing the influence of the explanatory variable, x_{it} – implementation of the explanatory variable for the *i-th* object in the *t-th* period, e_{it} – residuals that meet the classic assumptions: $E(e_{it}) = 0$ I $Var(e_{it}) = S^2_e$.

The model assessment is based on F statistics (calculated traditionally, based on the sums of squared deviations). At low p, lower than the accepted level of significance α (usually $\alpha = 0.05$), the decomposition of the intercept is considered justified. The evaluation of the prognostic properties of the model is done in a standard manner, using the determination coefficient (including the adjusted R^2). The estimation of panel models was made using the Gretl programme.

Results

Table 3 presents correlation coefficients between R&D expenditure and selected financial measures (ratios and absolute values) and macroeconomic indicators based on the cross-sectional and time-related sample (Polish voivodships in 2007–2015). Measures of enterprises' financial policy, such as the net result to total loans ratio, financial result from sales to net result ratio, net turnover profitability ratio or financial liquidity III ratio are strongly and positively correlated with R&D expenditure. This shows a fairly consistent picture of the investing companies, which are profitable operators, skilfully using financial leverage and maintaining high financial liquidity. It can also be observed in less visible correlations, such as the result of economic activity to long-term liabilities ratio, the result of economic activity to total loans ratio or the financial liquidity ratio I. This also testifies to the moderate nature of the investment policy of an enterprise.

The correlation analysis of the operating costs causes some concerns. A strong and positive relationship was found between R&D investment expenditure and the share of production costs of products in revenues from operating activities, as well as the share of variable costs in revenues from operating activities. It means that the propensity to invest increases as the operating margin decreases. This seemingly contradictory relationship, especially in the context of the positive correlation between investment outlays and profitability, may be explained by competitive conditions, in which logistics companies operate. Low operating margin forces companies to be more efficient, which may result in searching for new solutions and, as

Table 3

Correlation between R&D expenditure and selected financial and macroeconomic variables of Polish logistics companies (n = 144)

Variables		r	rho
X.2.1	*number of newly established logistics companies*	*0.001*	*0.262*
X3.1	share of production costs of products in revenues from operating activities	0.776	0.732
X3.2	share of variable costs in revenues from operating activities	0.931	0.901
X3.3	financial result from sales to net result ratio	0.803	0.533
X3.4	net turnover profitability ratio	0.880	0.818
X3.5	financial liquidity ratio I	*0.721*	*0.487*
X3.6	financial liquidity ratio III	0.961	0.872
X3.7	net result to total loans ratio	0.971	0.833
X3.8	*business result to long-term liabilities ratio*	*0.187*	*0.264*
X3.9	*result of economic activity to total loans ratio*	*0.024*	*0.187*
X3.10	*revenues from total activity (natural logarithm)*	*0.061*	*0.362*
X3.11	*financial costs to the financial result of business activities ratio*	*0.372*	*0.387*
X3.12	*share of the number of enterprises showing positive net profit in the total number of enterprises*	*0.054*	*0.072*
X3.13	*value of bank loans and total loans taken (natural logarithm)*	*0.053*	*0.061*
X3.14	*gross financial result burden – income tax*	*0.010*	*0.046*
X4.2	number of university graduates	0.684	0.736
X4.3	total number of enterprises	0.777	0.646
X4.4	length of motorways and expressways	0.707	0.492
X4.5	*length of public roads*	*0.193*	*0.501*

r – Pearson's linear correlation coefficient
rho – Spearman's rank correlation coefficient.
Correlation measure proper for a given pair of variables is grey shaded. Variables weakly correlated with investment spending are italicised.

Source: the author's calculations based on the Local Data Bank of the Central Statistical Office of Poland.

a consequence, in R&D activities. Thus, it means that the analysis includes mainly enterprises currently implementing development projects, which thanks to R&D have improved their performance and their investment activity is slowing down. A weak and positive correlation between R&D expenditure and the number of newly established logistics enterprises may support this conclusion. Every newcomer into the sector struggles with entry costs. Therefore, since industry operates at low margins, it must have a competitive advantage resulting from better organisation and ability to reduce costs. This, in turn, forces other competitors to make development efforts.

A very modest positive correlation can also be observed between R&D expenditure and the financial costs to financial result of business activities ratio. As regards other debt-related indices, we can say that development investments are primarily made by companies which use financial leverage. They are also larger operators. It must be remembered, however, that the strength of the analysed debt correlation is low, often negligible. Therefore, it cannot be used as a basis for far-reaching conclusions.

The total population of enterprises, as well as the development of road and motorway networks also positively correlate with R&D expenditure. A positive correlation with the total number of enterprises seems quite obvious – the larger the market, the bigger investment outlays in absolute terms. This correlation also informs us about the intensity of competition in the sector. The size of the market, especially its growth, does not have to motivate enterprises to invest. The adequate level of market development may be a sufficient factor determining the development of the enterprises. Thus, if they decide to invest in R&D it means that market growth is not sufficient or a big population of competitors necessitates development activities.

Infrastructural factors appeared to be a significant factor in the development of logistics companies. There is a positive relationship between R&D expenditure of logistic companies and the length of public roads, expressways and motorways. This correlation is connected with the number of companies. The availability of roads, especially expressways and highways, is a key factor in the choice of location. This is also confirmed by the correlative strength, significantly higher for motorways. The impact of the availability of university graduates is similarly important. Higher education institutions (HEIs) are located mostly in highly urbanised places. This also results in the availability of public roads, in particular motorways. A positive correlation with the number of university graduates may also result from their R&D engagement. In addition, a competitive labour market for young

Table 4

Spearman's rank correlation between R&D expenditure and selected financial and macroeconomic variables of Polish logistics companies (values by voivodships) (n = 9)

Voivodeship	X2.1	X3.1	X3.2	X3.3	X3.4	X3.5	X3.6	X3.7	X3.8	X3.9	X3.10	X3.11	X3.12	X3.13	X3.14	X4.2	X4.3	X4.4	X4.5
dolnośląskie	–0.036	0.179	0.179	0.179	0.321	0.179	0.321	**0.821**	0.000	–0.198	0.018	0.107	0.071	–0.250	0.143	0.250	–0.393	**0.714**	0.182
kujawsko-pomorskie	0.286	–0.357	–0.357	–0.107	–0.464	–0.107	0.286	–0.036	–0.071	0.000	0.071	0.464	0.071	–0.071	–0.143	–0.321	–0.107	–0.143	–0.036
lubelskie	0.107	**0.643**	**0.643**	0.179	0.250	0.286	**0.679**	**0.571**	**0.559**	–0.036	0.054	–0.143	0.000	–0.357	–0.357	0.179	–0.464	0.429	0.401
lubuskie	0.143	0.286	0.357	0.107	0.143	0.107	**0.821**	–0.036	0.214	0.000	0.071	–0.107	0.143	0.143	0.000	0.071	0.179	**0.643**	0.055
łódzkie	0.071	**–0.643**	**–0.643**	0.071	–0.464	0.321	–0.071	–0.179	**–0.786**	–0.144	–0.288	0.214	0.036	0.286	0.286	0.071	0.429	–0.393	–0.670
małopolskie	–0.429	0.357	–0.036	0.286	0.107	0.286	**0.536**	–0.464	0.107	0.018	0.429	0.321	0.143	0.143	0.143	–0.179	0.286	–0.143	–0.306
mazowieckie	–0.429	**0.929**	**0.893**	0.286	–0.286	0.357	**0.964**	**0.607**	0.357	–0.108	–0.071	0.393	–0.143	0.036	0.071	0.036	–0.108	**0.821**	0.893
opolskie	0.000	0.214	0.214	–0.107	–0.214	–0.107	0.179	0.214	**0.607**	**0.505**	–0.179	**0.607**	–0.250	–0.464	–0.464	–0.107	**–0.536**	–0.071	0.357
podkarpackie	0.018	**0.739**	**0.631**	0.288	0.252	0.360	–0.126	0.018	0.180	–0.327	–0.306	–0.468	0.090	0.360	0.360	0.396	**–0.739**	**0.847**	0.449
podlaskie	0.071	0.357	0.357	**0.536**	**0.750**	0.214	0.179	0.143	0.071	–0.234	**0.571**	–0.071	–0.054	0.143	–0.036	0.071	–0.214	–0.179	0.134
pomorskie	0.054	**0.607**	**0.607**	0.214	0.179	0.214	**0.714**	0.357	0.000	–0.107	**0.775**	**0.536**	0.321	–0.107	–0.107	–0.179	**0.501**	**0.607**	0.587
śląskie	0.071	0.464	0.464	–0.250	0.107	–0.429	0.250	**0.643**	0.036	0.429	–0.357	–0.286	–0.429	**–0.679**	–0.429	–0.321	0.450	0.393	0.523
świętokrzyskie	0.450	0.071	0.071	0.286	0.393	0.357	0.429	0.393	–0.071	–0.107	–0.306	**–0.607**	–0.429	0.036	0.036	0.107	0.214	0.286	0.073
warmińsko-mazurskie	0.214	0.036	–0.143	**0.857**	**0.607**	**0.821**	–0.143	0.179	**0.505**	**–0.685**	**0.714**	0.143	0.036	**0.643**	**0.607**	**0.714**	0.357	**–0.571**	–0.182
wielkopolskie	–0.143	0.000	0.000	–0.179	–0.143	–0.250	0.036	0.143	–0.143	0.270	–0.252	–0.357	–0.286	–0.429	–0.536	–0.286	0.143	–0.321	0.000
zachodnio pomorskie	0.429	0.214	0.286	0.000	0.393	0.143	**0.536**	**0.929**	–0.018	0.018	0.214	0.214	0.250	**–0.786**	**–0.714**	0.000	–0.393	**0.786**	0.898

Bolded coefficients indicate high or very high strength of correlation between variables. Markings – as in Table 3.

Source: the author's calculations based on the Local Data Bank of the Central Statistical Office of Poland.

people combined with good prospects for the development of the logistics sector certainly contributes to their interest in this industry. It is confirmed by high popularity of logistics studies, which results in an increased number of graduates employed in the logistics sector.

As we can judge from the data presented in Table 4, the relation between R&D expenditure and other characteristics of enterprises from the logistics sector and macroeconomic categories vary between voivodships. In Wielkopolskie and Kujawsko-Pomorskie voivodships, none of the pairs of considered variables is correlated at least at a moderate level. Therefore, financial situation of enterprises does not significantly correlate with R&D expenditure in these voivodships (in the logistics sector).

These relationships are much stronger in Warmińsko-Mazurskie voivodship where the higher the: ratio of the financial result from sales to the net result, net profitability ratio, financial liquidity I ratio, business result to long-term liabilities ratio, revenues from total activity, bank loans, total loans, and tax burden, the higher the average R&D investment expenditures in the sector (and vice versa). These relations are quite strong also in the following voivodships: Pomorskie, Zachodniopomorskie, Lubelskie, Opolskie, and Mazowieckie. Results for Lódzkie Voivodship are surprising in comparison to other voivodships: correlation coefficients are negative in many cases, though, unlike in other voivodships, R&D expenditures of logistic companies increase with the decrease in the business result to long-term liabilities ratio and the result of economic activity to total loans ratio. There is also a negative relation of development activities and the share of production costs of products in revenues from operating activities and the share of variable costs in revenues from operating activities. The first correlation may result from a wide use of debt-financing in R&D activities. An increase of debt at a constant economic result lowers the ratio. It also indicates a higher risk faced by logistics enterprises in Lódzkie Voivodship. The second dependence may mean better prospects for those companies which can use the operational leverage.

It is also worth noting that the correlation analysis is sometimes difficult to interpret. An example is Lódzkie Voivodship, where the road network (total) does not favour R&D development – a quite strong negative correlation was found. The situation is similar for Opolskie and Podlaskie voivodships, where a moderate negative correlation of investment outlays and the total number of enterprises was observed. A strong negative relation between R&D investments and the value of bank loans and total loans in Śląskie and Zachodniopomorskie voivodships is also difficult to explain.

Variables that most often appear as strong determinants of the R&D investment activity of the logistics sector in all voivodships are: the length of motorways and expressways, the length of public roads, the share of production costs of products in revenues from operating activities, the share of variable costs in revenues from operating activities, financial liquidity ratio III, and the net result to total loans ratio. These variables usually stimulate R&D expenditures. The result of economic activity to total loans ratio, the value of bank loans and total loans, revenues from total activity and the financial costs to the financial result of business activity ratio are also important determinants of R&D expenditures. Apart from the afore mentioned exceptions, these variables also contribute to the development expenditure of logistics companies, which confirms prior conclusions. Among the considered environmental conditions the impact of the motorway network development is the most positive (this applies in particular to the western part of Poland: Dolny Śląsk, Lubuskie Voivodship, Zachodniopomorskie, and also Mazowieckie, Pomorskie, and Podkarpackie Voivodships (as well as Warmińsko-Mazurskie Voivodship but in the opposite direction).

Since individual explanatory variables in many cases are too strongly correlated with each other, the panel model taking into account all the explanatory variables highlighted in earlier analyses showed collinearity, which was not fully justified in substantive terms. Therefore, we used estimates in several stages (options Models 1–3) (Table 5). Some explanatory variables were included in the list of significant determinants of investment activity in any option.

In the first step (Model 1), we adopted characteristics of the financial situation of enterprises, in relative terms, as explanatory variables (X3.1 –X3.7). We skipped X3.2 due to close collinearity. All these factors turned out to be significantly related to R&D expenditure. The negative parameter at variable X3.1 (the share of production costs of products in revenues from operating activities) may be surprising. It can be explained similarly to the above presented correlations designated for enterprises from the Lódź region. Other parameters are in line with expectations – assuming *ceteris paribus* that the higher the: financial result from sales to net result ratio, net turnover profitability ratio, financial liquidity ratio, and net result to total loans ratio, the higher the average R&D expenditure. In contrast with these factors, the impact of the business result to long-term liabilities ratio and the financial costs to the financial result of business activities ratio are irrelevant. It confirms the previous conclusions about little significance of debt in the development policy of logistics companies.

Table 5

Estimation results of R&D investment expenditure models for logistic enterprises (n = 144)

Explanatory variables	Model 1		Model 2		Model 3	
	b	p (test t)	b	p (test t)	b	p (test t)
const	162.304	0.02295*	–2165.35	0.06496*	–2336.269	0.00893*
X3.1	–3.128	<0.00001*				
X3.3	4.289	<0.00001*				
X3.4	6.109	0.00001*				
X3.5	5.012	<0.00001*				
X3.6	1.308	<0.00001*				
X3.7	0.795	0.00029*				
X4.2			14.398	0.04233*		
X4.3			121196	0.05477*		
X4.4			0.269	0.00369*		
X3.10					5126.409	0.00193*
Test F	F(15. 90) = 4.361; p<0.00001*		F(15. 93) = 30.818; p<0.00001*		F(15. 93) = 27.804; p<0.00001*	
R^2	0.9742		0.9003		0.9290	
R^2_{adj}	0.9657		0.8965		0.9104	

where: b – structural parameter estimator, p – probability of the test, R^2 – coefficient of determination, R^2_{adj} – adjusted coefficient of determination

Source: the author's calculations based on the Local Data Bank of the Central Statistical Office of Poland.

When building Model 2 we included infrastructure and macroeconomic determinants of R&D expenditure (X4.2–X4.5). The analysis was extended by adding the examination of the impact of the number of competitors (X2.1). Among these factors, the length of motorways and expressways, the number of university graduates and the total number of enterprises turned out to be significant. The increase in R&D expenditure made by logistics companies is favoured by higher values of these variables. In the context of previous correlation analyses, we may assume that this relationship has its source in the degree of urbanisation. The higher urbanisation, the better

operating conditions for the logistics industry and its capacity to implement R&D effects. Interestingly, the impact of competition concentration in the sector turned out to be irrelevant. The number of newly established logistics companies turned out to be irrelevant as well.

In the last model (Model 3) an attempt was made to include the characteristics of the financial standing of enterprises in nominal terms (X3.10, X3.13, X3.14). Among these factors, the size of the enterprise measured with the natural logarithm of revenues from total activity is significant. It has been demonstrated that larger companies conduct more intensive R&D activities *(ceteris paribus*). It is worth mentioning that all estimated models have good statistical properties (the explanation of the inputs variance is high, group effects are statistically significant, which justifies the use of panel models instead of the classic least squares method).

Conclusions

The study of the factors determining R&D expenditures does not confirm all the hypotheses formulated at the beginning of the article. First of all, there are no significant relationships with variables related to the intensity of competition. Neither the number of enterprises nor that of start-ups significantly determine the value of R&D expenditures of logistics companies. This may be the result of the above-mentioned significant fragmentation of the market. Small and micro companies operate locally and face structural constraints in access to capital investment financing. It means that very often equity contributed at start-up is the only investment capital. As already demonstrated, capital expenditures are constantly growing, but this is not due to the size of the sector. It follows that R&D activities are undertaken by larger enterprises. Their number does not change as dynamically as the value of R&D expenditures. Therefore, there is no reason to accept hypothesis 1.

Financial performance of enterprises seems to be the most important factor, although the research results are not unambiguous. A strong and positive relationship was found between R&D investment and the share of production costs of products in revenues from operating activities and the share of variable costs in revenues from operating activities. Although the panel model indicates an opposite relationship with one of these variables, it is difficult to find the basis for adopting hypothesis 2. We should assume that the propensity to invest in R&D increases as the operating margin decreases. A low operating margin forces companies to be more efficient, which may

lead to searching for new solutions, which, in turn, triggers R&D. Under such conditions, the company has limited possibilities to use financial leverage, which is vital for its financing policy.

The study showed that profitable logistics companies are more active in R&D activities. This dependence is strong, although it was not confirmed in all voivodships included in the exercise. Yet, this gives grounds for accepting part of hypothesis 3. Profitability of a business seems a natural condition for increasing efficiency by incurring higher debt. However, the research did not show a significant link between the increase of the financial result and debt or financial costs. Such dependencies either do not exist or are statistically weak. The only exception is the change in the net result to total loans ratio, strongly positively related to R&D expenditure. Therefore, we can presume that development activities are accompanied by a conservative financing policy. Nevertheless, there is no indisputable evidence that this is the case; hence hypothesis 3 cannot be accepted in this part. On the other hand, there are no contraindications as to the assessment of liquidity in accordance with the adopted hypothesis. Both liquidity measures are statistically significant and positively relate to R&D expenditure, although this relationship is not observed at the level of voivodships. Therefore, in the light of the performed analyses, hypothesis 3 can be only partially accepted.

The analysis showed that the size of a company and R&D activity correlate positively. Although it is not always true for voivodships, the correlation leaves no doubt at the general level. Therefore, there are no grounds for rejecting hypothesis 4. The impact of urbanisation causes some concerns. A relationship between R&D and the number of enterprises or university graduates was demonstrated. However, development activity is not directly related to the region's wealth, measured with GDP. For this reason, hypothesis 5 can be accepted only partially. The same applies to hypothesis 6. A strong dependence of R&D values on the length of expressways and motorways was observed, but not on that of public roads. This may be the effect of a symbolic increase in the length of public roads in relation to the increase in the length of expressways and motorways (it amounted to at least over a dozen percent annually) in the period under consideration.

Studies of voivodship data also do not allow us to clearly identify local determinants of R&D in logistics companies, although in many places the results obtained are consistent and close to national ones. On the general level, the study showed that R&D activities of logistics firms are primarily carried out by larger companies, which pursue a conservative financing policy based on low indebtedness and high liquidity. This is in line with the

results of previous research and points to the lack of differences between R&D of logistics companies and companies from other sectors. These firms operate in a low margin environment, which significantly limits development opportunities. The study did not confirm the impact of competition on R&D activity, which may result from the growth of the sector itself. However, the availability of road infrastructure and urbanised areas is a factor that indisputably affects R&D.

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Determinants of R&D Activity – Analysis of the Polish Logistics Sector

Summary

The aim of the article is to identify factors that significantly affect the level of R&D and to determine the strength of this impact. The research involved 950 Polish logistics companies. Data from the Local CSO Data Bank from 2007–2015 were used for the study. As explanatory variables, three groups of potential R&D determinants of the studied entities were distinguished: intensity of competition, financial performance of the enterprise and macroeconomic conditions. The analysis was based on descriptive statistics, Pearson's correlation analysis and Spearman's rank correlation coefficient and the use of panel models, estimated on the basis of a cross-sectional sample. The statistical survey was carried out both on aggregate national values and using data at the voivodship level. The study showed that R&D activities of logisticsfirms are carried outprimarily by larger companies, which conduct a conservative financing policy based on low indebtedness and high liquidity.These firms operate in a low marginenvironment, which significantly limits development opportunities. The study did not confirm the impact of competition on R&D activity, which may result from the growth of the sector itself. However, the availability of road infrastructure and urbanized areas is a factor that indisputably affects R&D.

Key words: research and development, logistics, company, Poland

Determinanty działalności badawczo-rozwojowej – Analiza polskiego sektora logistycznego

Streszczenie

Celem artykułu jest identyfikacja czynników istotnie wpływających na poziom inwestycji B+R oraz określenie siły tego oddziaływania. Badaniu poddano 950 polskich firm logistycznych. Do badania wykorzystano dane zawarte w Lokalnym Banku Danych GUS z okresu 2007–2015. Jako zmienne objaśniające wyodrębniono trzy grupy potencjalnych determinant B+R badanych podmiotów: natężenie konkurencji, uwarunkowania finansowe przedsiębiorstwa oraz uwarunkowania makroekonomiczne. Analizę przeprowadzono w oparciu o statystki deskryptywne, ocenę korelacji Pearsona i współczynnika korelacji rang Spearmana oraz zastosowanie modeli panelowych, estymowane w oparciu o próbę przekrojowo-czasową. Badanie statystyczne przeprowadzono zarówno na zagregowanych wartościach ogólnopolskich, jak i posługując się danymi na poziomie województwa. Badanie wykazało, że działania B+R firm logistycznych realizowane są przede wszystkim przez większe przedsiębiorstwa prowadzące zachowawczą politykę finansowania opartą na niewielkim zadłużeniu i wysokiej płynności finansowej. Firmy te funkcjonują w warunkach niskiej marży, która istotnie ogranicza możliwości rozwojowe. Badanie nie potwierdziło natomiast wpływu konkurencji na aktywność B+R, co może wynikać ze wzrostu samego sektora. Czynnikiem bezdyskusyjnie wpływającym na B+R jest natomiast dostępność do infrastruktury drogowej i obszarów zurbanizowanych.

Słowa kluczowe: badania i rozwój, logistyka, przedsiębiorstwo, Polska

Детерминанты исследовательско-развивающей деятельности – Анализ польского логистического центра

Резюме

Цель статьи - выявить факторы, существенно влияющие на уровень инвестиций B+R [НИКР], и определить силу этого воздействия. В исследовании участвовали 950 польских логистических компаний. В целях исследования были использованы данные, содержащиеся в Локальном банке данных GUS

[Главного статистического управления] за 2007–2015 годы. В качестве объясняющих переменных были выделены три группы потенциальных детерминантов НИОКР исследуемых субъектов: интенсивность конкуренции, финансовые условия предприятия и макроэкономические условия. Анализ основывался на описательной статистике, корреляционном анализе Пирсона и ранговом коэффициенте корреляции Спирмена, а также применении моделей панельных данных, полученных на основе образца поперечного сечения. Статистическое исследование проводилось как на основе совокупных национальных ценностей, так и посредством использования данных на уровне воеводства. Результаты исследования показывают, что деятельность логистических компаний в области НИОКР в основном осуществляется крупными компаниями, проводящими консервативную политику финансирования, опирающуюся на низкую задолженность и высокую финансовую ликвидность. Эти компании функционируют в условиях низкого уровня маржи, которая в значительной степени ограничивает возможности развития. Исследование, однако, не подтвердило влияния конкуренции на активность НИОКР, что может быть результатом увеличения самого сектора. В то же время фактором, влияющим на НИОКР, является доступ к дорожной инфраструктуре и урбанизированным зонам.

Ключевые слова: иследования и развитие, логистика, предприятие, Польша

Cite as:

Marszałek, J. (2018) 'Determinants of R&D Activity – Analysis of the Polish Logistics Sector'. *Myśl Ekonomiczna i Polityczna* 3(62), 62–86. DOI: 10.26399/meip.3(62).2018.32/j.marszalek

Cytuj jako:

Marszałek J., *Determinants of R&D Activity – Analysis of the Polish Logistics Sector [Determinanty działalności badawczo-rozwojowej – Analiza polskiego sektora logistycznego]*, „Myśl Ekonomiczna i Polityczna" 2018 nr 3(62), s. 62–86. DOI: 10.26399/meip.3(62).2018.32/j.marszalek