IER
INSTITUTE
OF ECONOMIC
RESEARCH

**R&D Activity and Core Business Efficiency
on the Example of Technology Companies**

Tomasz L. Nawrocki

The paper submitted to

VIIIth INTERNATIONAL CONFERENCE ON APPLIED ECONOMICS

CONTEMPORARY ISSUES IN ECONOMY
under the title

MARKET OR GOVERNMENT?

Institute of Economic Research and Polish Economic Society Branch
in Toruń

18-19 June 18-19, 2015, Toruń, Poland

Toruń, Poland 2015

Tomasz L. Nawrocki

Tomasz.Nawrocki@polsl.pl
Silesian University of Technology, Poland

R&D Activity and Core Business Efficiency on the Example of Technology Companies

Abstract: *Taking as a basis for discussion the Schumpeter's innovation theory, this paper analyses the relationship between enterprises activity in the field of research and development and their efficiency at the core business level. This analysis was performed in two ways – with the assumption shift in time between research and development activities and companies business efficiency and without it – using the Spearman's rank correlation coefficient. The sample was accounted for 252 companies from the technology sector, whose shares are traded on NYSE or NASDAQ, and the analysis time period consisted of three years (2011-2013). Results obtained in the course of analysis generally indicate lack of strong relationship between distinguished categories. Noticeable, but only at moderate level, positive correlation was found in both considered approaches only in respect of relationship between the intensity of expenditures on research and development or y/y change of these expenditures and gross margin on sales. Therefore, it seems to be relevant to extend this research at least in such directions as: identification and characterization of factors determining efficiency of companies research and development activities, as well as examination considered relationship taking into account business diversity within the sector and wider time shift between realized research and development activities and various measures of core business efficiency.*

Introduction

Considerations concerning relationship between enterprises activity in the field of research and development (R&D) and their business results can be classified as one of the most popular research topics in the literature over the last few decades. Their basis is considered to be the Schumpeter's

theory of innovation (Schumpeter, 1950), according to which the innovation (which one of the main expressions are R&D activities) provides foundation for company's long-term growth and success in market economy. Despite many studies in this area the interest in this topic remains at a high level, because multiplicity and pace of changes taking place in the companies themselves and their close and distant environment, creates the need for continuous verification of conclusions reached earlier, as well as it supports undertaking research in new directions. In this regard it should be noted that the studies undertaken so far have mainly been focused on evaluation of the relationship between the enterprises activity in the field of research and development and changes in their basic output values such as revenue from sales or net profit. It is necessary to add here too, that this evaluation is generally positive, which is quite well documented in the literature (e.g., Morbey, 1988; Klette, 1996; Hanel, 2002; Artz *et al.*, 2003; Feeny & Rogers, 2003; Tsai & Wang, 2004; Ramirez & Hachiya, 2008; Chang & Su, 2010).

At this point it is worth noting, that the improvement in company's performance can be a result of extensive management (increasing the involvement of resources, eg. labor force or tangible assets) or intensive one (releasing of reserves existing in possessed resources), however requirements of rational business activity corresponds better to the second of these management options, because it is characterized by more favorable efficiency measures, such as labor productivity, assets turnover or return on sales (Bednarski, 1979; Jonek-Kowalska, 2013).

Intensive management is usually equated with technical and organizational progress, adopting most often form of innovation process, which one of the early stages are research and development activities. Therefore, in considerations about the relationship between technical and organizational progress, innovation and research activities, it is often assumed, that progress is a function of research development, suggesting at the same time that the greater the expenditures are on that activities, the higher the rate of progress is and more dynamic innovation processes (Lichtarski, 1999).

At the same time, however, in the literature, this relationship with respect to the enterprise efficiency (which is a result of technical and organizational progress) is poorly documented, and after all the efficiency, rather than changes in individual financial data, is one of the main factors of companies competitiveness and their reputation among existing and potential stakeholders (Jonek-Kowalska & Michalak, 2012; Szwajca, 2014; Gorczyńska, 2010).

Therefore, as the main objective of this article it was adopted to examine the relationship between enterprises research and development activities and their efficiency at the core business level, which is first and the key determinant of this activity outcome, materialized in the form of various innovations. For the purpose of achieving this objective, two hypotheses were verified.

H1: There is a positive relationship between enterprises activity in the field of research and development and their efficiency on the core business level.

H2: Positive results of enterprises research and development activities on their efficiency on the core business level can be shifted in time.

The first of the hypotheses mentioned above is a direct result of recommendations formulated in the literature, regarding the relationship between research and development activities and companies business efficiency. The basis for formulation of the second hypothesis was the specificity of research and development activities, which one of the main expressions is generally indefinite period of materialization, often counted not in months or quarters, but in years to come. Thus, the impact of this activity on the core business efficiency is not necessarily associated with the period of incurring expenditures on research and development.

Data, assumptions and research methodology

Due to the availability of data on research and development expenditures, in determining the research sample the focus was on companies from technology sector, whose shares are traded on NYSE or NASDAQ. Additional, besides the data disclosure on research and development costs, research sample selection criteria were: company's annual reporting period from January to December, financial statements prepared in accordance with SEC standards expressed in US dollars, and finally availability of company's profile, along with basic financial data, on the yahoo.finance.com portal (the main source of data). As a result, the research sample consisted of 252 companies.

The time range of the analysis was limited to a period of three years (2011-2013), which was dictated by the availability of data on the yahoo.finance.com portal.

In order to verify the research hypotheses, first the criteria for assessing involvement of analysed companies in the research and development activities and the criteria for assessing their efficiency at the core business

level were distinguished. In case of research and development activities the focus was in particular on one of the key indicators in this area, proposed in the Frascati (OECD, 2002) and Oslo methodology (OECD/Eurostat, 2005), which is an intensity ratio of expenditures on research and development – (R&D)IR (relation costs of research and development to sales revenue). As a complementary assessment criteria in this area were used growth y/y indices of expenditure on research and development – ^{v}(R&D)Exp – and mentioned above intensity ratio – ^{v}(R&D)IR. Moreover, in order to take into account continuity of research and development activities in periods longer than one year, as additional criterion was adopted also the average value of its intensity ratio in a period of two or three years – Avg.(R&D)IR.

With respect to the analysed companies as the core business efficiency criteria into account were taken: the gross profit margin – GPM (relation of gross profit to sales revenue) – total assets turnover – TAT (relation of sales revenue to average total assets) – and their growth y/y indices – ^{v}GPM, ^{v}TAT. Therefore, assessment of efficiency had both static (relation effect to expenditure) and dynamic (changes of static performance measures in time) dimension.

Limitation in evaluation of companies efficiency only to their core business area is primarily dictated by the fact that it is the first and also the main area of business, from the perspective of both sales revenues and costs, to look for materialized effects of R&D activities in the form of various innovations brought into service (product, process, marketing and organizational). Additional factor in favor of limitation to this area is possibility of falsification the efficiency indicators calculated on the basis of further profit/loss levels in income statement as a result of one-off events (restructuring costs, impairment costs, foreign exchange differences, gains or losses on investments), which in case of core business are unlikely to occur.

The above measures were then used to investigate the relationship between the researched technology companies R&D activity and their efficiency at the core business level. Due to the finding of normal distribution lack for some of considered variables series, in order to verify the hypotheses it was decided to use the Spearman's rank correlation coefficient given by the formula:

$$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n \cdot (n^2 - 1)}, \qquad d_i = Rx_i - Ry_i \qquad (1)$$

where:
   r_s – the Spearman rank correlation coefficient,
   d_i – difference in paired ranks,
   n – number of cases.

According to the general interpretation of correlation coefficient indicated above, values closer to -1 and 1 indicate strong correlation between examined variables (respectively negative and positive), and values close to 0 indicate its lack.

For correlation calculation between previously identified variables the Statistica software was used, getting additional information about the statistical significance of obtained results with p-value at 0.05 level.

In order to verify research hypotheses in the first place it was assumed to calculate for different annual periods of the study a correlations between:
- (R&D)IR,
- ^{v}(R&D)IR,
- ^{v}(R&D)Exp,

and adequate for these periods:
- GPM,
- TAT,
- ^{v}GPM,
- ^{v}TAT.

Then, in case of second research hypothesis verification, for correlation coefficients calculation a list of variables regarding involvement in research and development assessment was extended by the average values of expenditures intensity – Avg.(R&D)IR – within two (2011-2012 and 2012-2013) and three (2011-2013) years, and in case of variables regarding efficiency assessment, it was founded to take values shifted by one or, if possible, by two-year periods.

Overall summary of presented above assumptions concerning verification of formulated hypotheses is presented in table 1.

Tomasz L. Nawrocki

Table 1. Assessment criteria pairs for research hypotheses verification

|	GPM_2011	GPM_2012	GPM_2013	TAT_2011	TAT_2012	TAT_2013	^{v}GPM_2012/2011	^{v}GPM_2013/2012	^{v}TAT_2012/2011	^{v}TAT_2013/2012
(R&D)IR_2011	H1	H2	H2	H1	H2	H2	H2	H2	H2	H2
(R&D)IR _2012	—	H1	H2	—	H1	H2	H1	H2	H1	H2
(R&D)IR _2013	—	—	H1	—	—	H1	—	H1	—	H1
^{v}(R&D)IR_2012/2011	—	H1	H2	—	H1	H2	H1	H2	H1	H2
^{v}(R&D)IR_2013/2012	—	—	H1	—	—	H1	—	H1	—	H1
Avg.(R&D)IR_2011-2012	—	H2	H2	—	H2	H2	H2	H2	H2	H2
Avg.(R&D)IR_2012-2013	—	—	H2	—	—	H2	—	H2	—	H2
Avg.(R&D)IR_2011-2013	—	—	H2	—	—	H2	—	H2	—	H2
^{v}(R&D)Exp_2012/2011	—	H1	H2	—	H1	H2	H1	H2	H1	H2
^{v}(R&D)Exp_2013/2012	—	—	H1	—	—	H1	—	H1	—	H1

Source: Own work.

Results

In order to verify mentioned in the introduction research hypotheses, in the first place for the companies forming research sample there were collected financial data (sales revenue, gross profit on sales, research and development costs, total assets) and calculated specified in the methodological part of the article criteria for assessing their activity in the field of research and development and efficiency at the core business level. The dispersion of their values in each period of analysis, which approximates the specifics of analysed technology companies, is shown in Figures 1 and 2.

As it can be seen, the value range of each assessment criteria in case of considered technology companies is quite substantial – the largest for TAT, the smallest for the (R&D)IR – what partially can be explained by the business variation within this sector – in the yahoo database,

technology sector consists of 32 industries (sub-sectors) (see: http://biz.
yahoo.com/p/8conameu.html).

Figure 1. Raw data and median of analysed technology companies static
assessment criteria in the field of R&D activities and core business efficiency
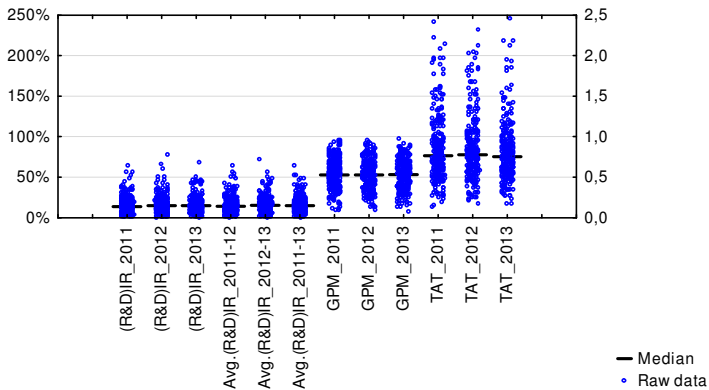
Source: Own calculations based on data from www.yahoo.finance.com

Figure 2. Raw data and median of analysed technology companies dynamic
assessment criteria in the field of R&D activities and core business efficiency
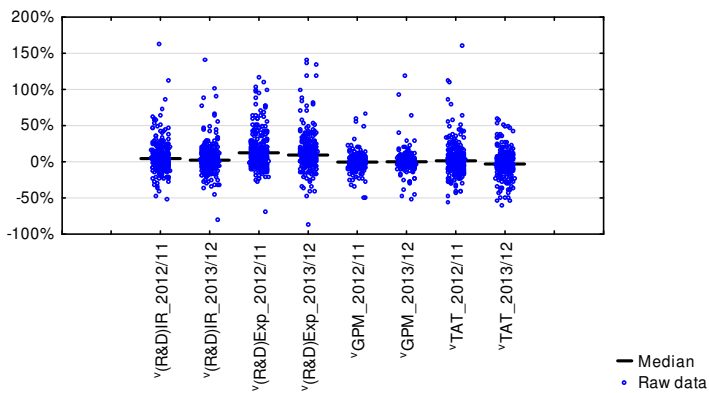
Source: Own calculations based on data from www.yahoo.finance.com

Simultaneously, however, it should be noted, that in case of static
assessment criteria (Figure 1) there are generally approximate ranges
of raw data in each period of analysis, while in case of dynamic assessment
criteria (Figure 2) some deviations from the main range. This has,

of course, its impact on median values, which, in relation to can be seen the static criteria are at similar level in each period of analysis, and in case of dynamic criteria show slightly greater differentiation (Table 2).

Table 2. Median values for each assessment criteria

	2011	2012	2013
(R&D)IR	13,6%	15,1%	15,0%
GPM	53,1%	53,0%	53,1%
TAT	0,765	0,776	0,755
	2011-12	2012-13	2011-13
Avg.(R&D)IR	14,3%	15,5%	15,1%
	-	2012/11	2013/12
^{v}(R&D)IR	-	4,2%	1,9%
^{v}(R&D)Exp	-	12,6%	9,1%
^{v}GPM	-	-0,4%	-0,2%
^{v}TAT	-	1,2%	-3,3%

Source: Own calculations.

With a set of considered variables the first research hypothesis H1 were verified. For this purpose, using Spearman's rank correlation coefficient (1), the relationship between indicated in the methodological part of the article criteria for assessing companies activity in the field of research and development and their core business efficiency in the same periods was calculated. Calculations were carried out in two ways – regarding all cases (A – All Cases) and eliminating outlier cases (WO – Without Outlier Cases). Obtained results are presented in Table 3. With bold lettering were highlighted ones, that are statistically significant with p-value at 0.05 level.

Table 3. Spearman's rank correlation coefficients regarding verification of the hypothesis H1

		(R&D)IR			^{v}(R&D)IR		^{v}(R&D)Exp	
		2011	2012	2013	2012	2013	2012	2013
GPM	A	**0,381**	**0,380**	**0,395**	-0,096	0,000	**0,332**	**0,210**
	WO	**0,390**	**0,385**	**0,410**	-0,099	-0,039	**0,316**	**0,169**
TAT	A	-0,052	-0,054	**-0,142**	-0,116	-0,110	0,039	-0,041
	WO	-0,013	-0,062	**-0,128**	-0,090	-0,052	0,038	0,007
^{v}GPM	A	-	0,011	-0,036	**-0,227**	**-0,140**	**0,125**	-0,036
	WO	-	0,019	-0,035	**-0,201**	**-0,101**	**0,137**	-0,038
^{v}TAT	A	-	**-0,125**	**-0,167**	**-0,406**	**-0,420**	**0,340**	**-0,246**

	WO	-	**-0,132**	**-0,163**	**-0,359**	**-0,386**	**0,340**	**-0,206**

Source: Own calculations.

Taking into account obtained results it can be concluded, that in case of analysed technology companies the hypothesis H1 is only slightly confirmed. Noticeable, but only at moderate level, positive correlation between the research and development activities of examined companies and their efficiency at the core business level in the same period occurred only in relation to the pairs formed by the gross margin on sales and the intensity ratio of expenditures on research and development or y/y changes of this expenditures. In other cases, obtained results indicate the absence of noticeable correlation or even a negative one (mainly it concerns total assets turnover and its y/y changes).

Following the assumptions described earlier in the methodological part, in the same way the hypotheses H2 was verified. Obtained results are presented in Table 4. With bold lettering were highlighted ones, that are statistically significant with p-value at 0.05 level.

Table 4. Spearman's rank correlation coefficients regarding verification of the hypothesis H2

$P_{(R\&D)A}$ /P_{CBE}*		(R&D)IR			Avg.(R&D)IR				^{v}(R&D)IR	^{v}(R&D)Exp
		2011 /2012	2012 /2013	2011 /2013	2011-12 /2012	2011-12 /2013	2012-13 /2013	2011-13 /2013	2012/11 /2013	2012/11 /2013
GPM	A	**0,402**	**0,393**	**0,411**	**0,395**	**0,407**	**0,407**	**0,409**	-0,098	**0,322**
	WO	**0,410**	**0,396**	**0,417**	**0,414**	**0,425**	**0,415**	**0,426**	-0,119	**0,281**
TAT	A	-0,013	-0,104	-0,077	-0,033	-0,091	-0,091	-0,116	-0,042	-0,093
	WO	-0,005	-0,100	-0,056	-0,040	-0,082	-0,117	-0,103	-0,019	-0,066
^{v}GPM	A	0,086	0,012	0,025	0,046	0,021	0,021	0,000	-0,071	-0,059
	WO	0,082	-0,001	0,016	0,039	0,018	-0,013	-0,001	-0,089	-0,068
^{v}TAT	A	0,007	-0,038	-0,061	-0,061	-0,054	-0,054	-0,098	**0,144**	**-0,244**
	WO	-0,025	-0,054	-0,054	-0,089	-0,050	-0,101	-0,093	**0,136**	**-0,227**

* $P_{(R\&D)A}$ – Period of R&D Activities; P_{CBE} – Period of Core Business Efficiency

Source: Own calculations.

Just as it was in case of the hypothesis H1 verification, also in relation to the hypothesis H2, obtained results only slightly confirm its truthiness. Noticeable, but again only at moderate level, positive correlation between research and development activity of analysed companies and their time-shifted efficiency at the core business level was only for pairs formed by the gross margin on sales and the intensity ratio of expenditures

on research and development, its average value in periods of two and three years, or y/y changes of this expenditures. In other cases, obtained results indicate the absence of noticeable correlation.
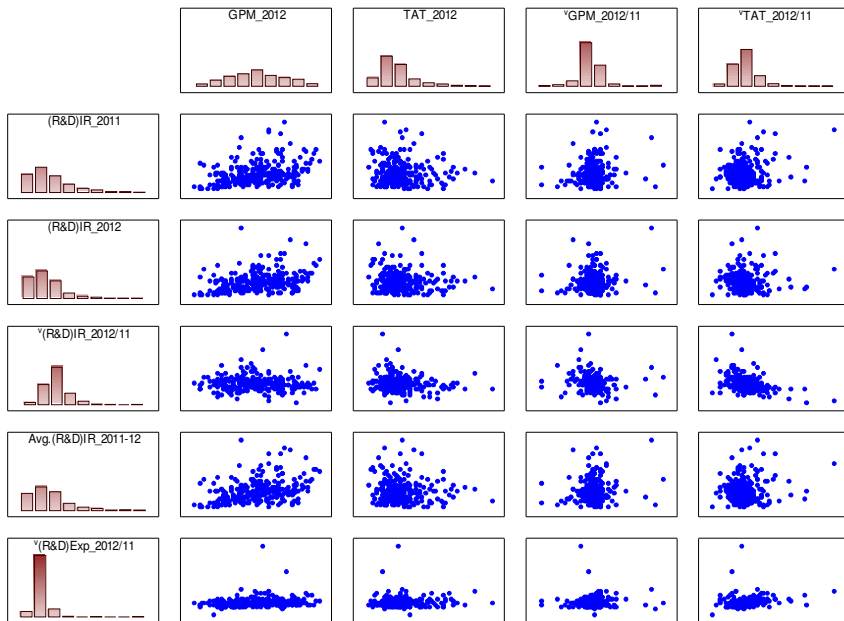
As a supplement, and also results confirmation, that were discussed above, in Figures 3, 4 and 5 are shown scatterplots of each assessment criteria pairs with their values distributions.

Figure 3. The Scatterplots of assessment criteria pairs from the viewpoint of efficiency measures for the year 2011.
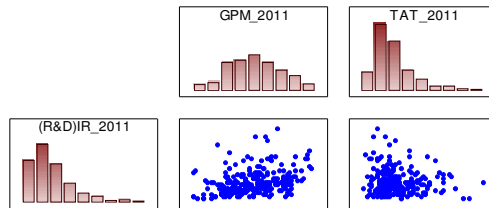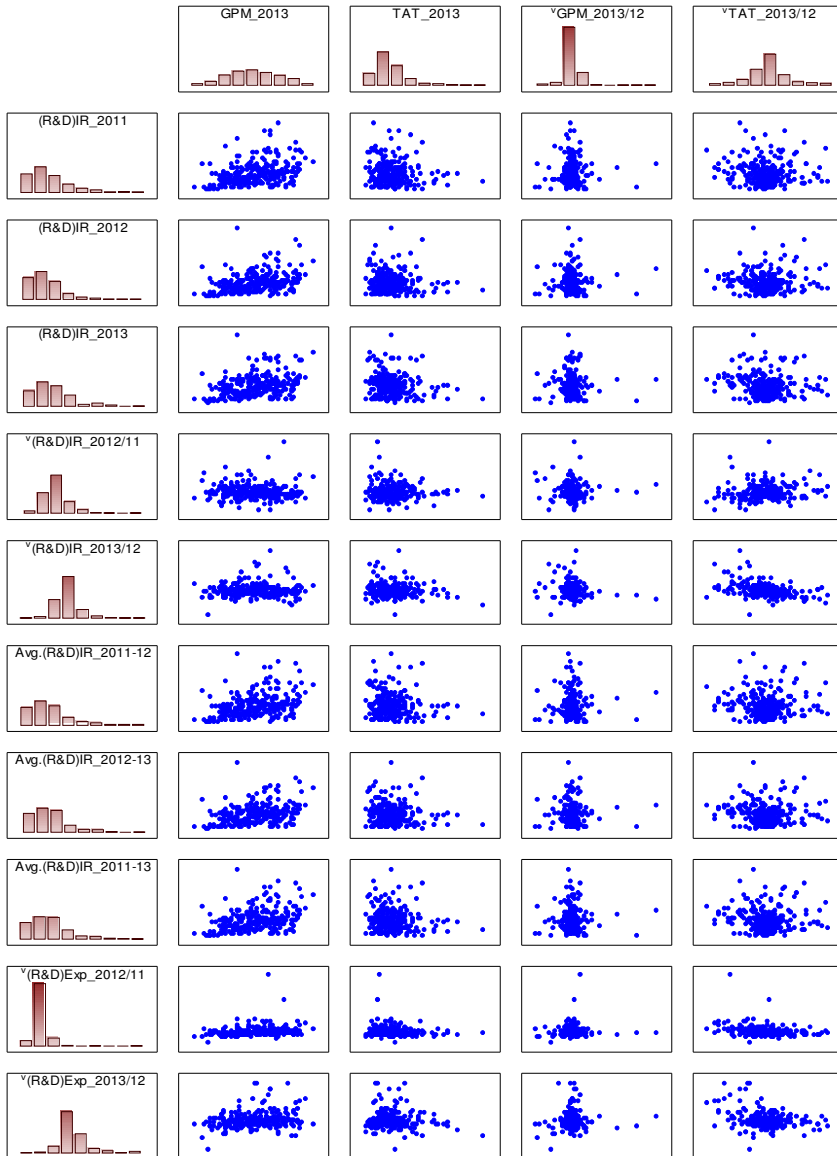

Source: Own work in Statistica

Figure 4. The Scatterplots of assessment criteria pairs from the viewpoint of efficiency measures for the year 2012.

Figure 5. The Scatterplots of assessment criteria pairs from the viewpoint of efficiency measures for the year 2013.

Source: Own work in Statistica

Conclusions

Although the results of performed analysis cannot be considered as an indication of the complete lack of any correlation between the research and development activities of technology companies and their efficiency at the core business level, but at the same time, they highlight the significant differences in the situation of entities within the considered sector. On one hand, this diversity can be a result of only false homogeneity of particular technology companies business specificity (as it was noted earlier, within considered sector is up to 32 industries), and on the other hand (in particular in relation to the hypothesis H2) of adopting too short period shifts between expenditures on R&D and measures of efficiency.

Therefore as justified can be considered deepening the research in this area, focusing firstly on the research sample selection level not on general sectors of the economy, but more homogeneous, in terms of their characteristics, industries (sub-sectors), and secondly on the data time series extension to more than three years.

At the same time, regardless of the abovementioned possible reasons for the differentiation of entities situation in relation to their engagement in research and development activities and efficiency at the core business level, its occurrence can also be identified with some factors specific to the individual companies, thus in some of them R&D activity is more efficient (characterized by higher rates of profitability and productivity, and their improvement over time) than in others. Deepening the research in this direction can also be regarded as justified, especially in the context of R&D efficiency impact on companies market assessment or their reputation assessment from the perspective of different interest groups.

References

Artz, K.W., Norman, P.M., Hatfield, D.E. & Cardinal, L.B. (2010). *A longitudinal study of the impact of R&D, patents, and product innovation on firm performance*. Journal of Product Innovation Management, 27(5). http://dx.doi.org/10.1111/j.1540-5885.2010.00747.x

Bednarski, L. (1979). *Analiza ekonomiczna*. Warszawa: PWE.

Chang, H. & Su, C. (2010). *Is R&D always beneficial*? Review of Pacific Basin Financial Markets and Policies, 13(1). http://dx.doi.org/10.1142/S021909151 0001809

Feeny, F. & Rogers, M. (2003). *Innovation and performance*: *benchmarking Australian companies*. The Australian Economic Review, 36(3).

Gorczyńska, A. (2010). *Problem pomiaru efektywności przedsiębiorstwa*. Zeszyty Naukowe Wyższej Szkoły Ekonomiczno-Społecznej w Ostrołęce, No. 8.

Hanel, P. & St-Pierre, A. (2002). *Effects of R&D spillovers on the profitability of companies*. Review of Industrial Organization, 20(4).

Jonek-Kowalska, I. & Michalak, A. (2012). *Ryzyko, koszt kapitału i efektywność w procesie finansowania inwestycji rozwojowych w górnictwie węgla kamiennego*. Warszawa: PWN.

Jonek-Kowalska, I. (2013). *Różne spojrzenia na efektywność przedsiębiorstwie*. In: M. Turek (Ed.), Analiza i ocena kosztów w górnictwie węgla kamiennego w Polsce w aspekcie poprawy efektywności wydobycia. Warszawa: Difin.

Klette, T.J. (1996). *R&D, scope economies, and plant performance*. The RAND Journal of Economics, 27(3). http://dx.doi.org/10.2307/2555841

Lichtarski, J. (1999). *Podstawy nauki o przedsiębiorstwie*. Wrocław: Wydaw. AE im. O. Langego we Wrocławiu.

Morbey, G.K. (1988). *R&D*: *Its relationship to company performance*. Journal Product Innovation Management, 5(3). http://dx.doi.org/10.1111/15405885.530191

OECD (2002). *Frascati Manual*: *Proposed Standard Practice for Surveys on Research and Experimental Development*. Paris: OECD Publishing.

OECD/Eurostat (2005). *Oslo Manual*: *Guidelines for Collecting and Interpreting Technological Innovation Data*. Paris: OECD Publishing. http://dx.doi.org/10.1787/9789264192263-en

Ramirez, P.G. & Hachiya, T. (2008). *Measuring the contribution of intangibles to productivity growth*: *a disaggregate analysis of Japanese firms*. Review of Pacific Basin Financial Markets and Policies, 11(2). http://dx.doi.org/10.1142/S0219091508001301

Schumpeter, J. (1950). *Capitalism, Socialism, and Democracy*. New York: Hamper & Brothers.

Szwajca, D. (2014). *Budowanie reputacji przedsiębiorstwa poprzez innowacyjność*. Zeszyty Naukowe Politechniki Śląskiej, seria: Organizacja i Zarządzanie, No. 74.

Tsai, K. & Wang, J. (2004). *The R&D performance in Taiwan's electronics industry*: *a longitudinal examination*. *R&D Management*, 34(2). http://dx.doi.org/10.1111/j.1467-9310.2004.00332.x

Industries classified within technology sector. Retrieved form http://biz.yahoo.com/p/8conameu.html (20.12.2014).

Source data of analysed companies. Retrieved form http://finance.yahoo.com (20.12.2014).