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THE ROLE OF ACADEMIC ENTREPRENEURSHIP IN THE COMMERCIALIZATION OF R&D OUTCOMES IN POLAND

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SPIS TREŚCI

ABSTRACT

The paper aims to examine determinants of R&D activity conducted by the non-financial Polish private limited liability and not-listed joint-stock companies, with the special focus on the academic entrepreneurship (firms whose management and/or supervisory board consists of at least one person with PhD or professor degree). The study intends to identify factors, which determine decisions made by management concerning commercialization of the results of the research and development activity, measured by the share of the capitalized expenditures on R&D in the fixed assets, based on literature review, the spatial statistics of patents and the probit panel analysis. Among factors influencing the R&D costs capitalized in the balance sheet we analyze firm size, ability to self-financing with the use of cash flow from operational activity, cash holdings, grants, availability of financing sources (bank loans, corporate bonds and share issue) and leverage. We also take into account companies' growth opportunities and operational risk, that as we suppose, play a crucial role in the academic entrepreneurship in comparison to more stable companies' managed by persons outside of the academia. The data used for analysis contains 23,667 non-public non-financial Polish limited liability and joint-stock companies for the period of 2003-2013 (235,046 firm-year observations). Findings of our research show that the effects of commercialization of the R&D activity's outcomes positively depend on grants, the ability to self-financing, firm size, while are negatively influenced by growth opportunity and operational risk, especially in the case of academic entrepreneurship.

Keywords: R&D, expenses on R&D activity, commercialization, academic entrepreneurship, grants, finance sources.

1. INTRODUCTION

Despite the high intellectual potential of academia in innovative sectors, Polish universities concentrate mainly on fundamental research. They lack effective commercialization tools for R&D outcomes. The existing technology transfer gap between basic research (conducted on universities and institutes mainly in the Lodz, the Lesser Poland, the Mazovian and the Lower Silesian voivodeships) and the commercialization of the results can be closed by companies with academics in management or/and supervisory boards which manage the technology transfer from universities and research institutes to industrial companies. However, this process requires favourable regulations, successful practices and considerable expenses on R&D work in form of grants, subsidies, but also funds gained by share issue on stock exchange. Debt financing of the commercialization of R&D outcomes is complicated with the risk of failure. Besides finance sources, to survive and grow, as well as to continue their R&D activity, scientists setting up companies need markets interested in their value proposition to increase sale and raise cash flow from operations and limit operational risk linked to the R&D activity.

In this paper we try to explore the determinants of corporate decision to commercialize the results of research and development activity (measured by the level of expenditures on development works - results of the R&D activity - capitalized in the balance sheet), with particular emphasis on the role of scientists in the management or supervisory of the company. We aim to compare determinants of the level of expenses on R&D activity between academic enterprises (managed and/or supervised by academics), and all private companies managed also by people from the outside of academic environment, based on the probit panel data analysis. Our analysis covers several aspects, including impact of researchers (doctors and professors) in management or/and supervisory board, operational risk, growth opportunities, research grants and subsidies and access to financing both internal (cash flow from operational activity, cash holdings) and external (debt including bank loans and borrowings, corporate bonds and share issue), mentioned in different streams of literature. We would also recognize an impact of patents and a localization close to academic centers and scientific institutes on R&D activity conducted by scientists and commercialization of the R&D outcomes through establishing a company as an example of academic entrepreneurship.

The rest of the paper is organized as follows. In the first part, we provide a literature review referring to the main points of our analysis. In the next section, we present the spatial statistics' analysis of patents registered in Poland by four types of entities. Then, we state our four hypotheses, describe the research sample and define variables for panel probit analysis. The main section of our study contains the panel probit analysis and the interpretation of our results. Finally, we provide conclusions, a short discussion and suggestions for possible directions of further research.

2. DETERMINANTS OF R&D ACTIVITY DEVELOPMENT - A LITERATURE REVIEW

2.1. FIRM SIZE

Schumpeter (1950) argues that large companies have the resources that they can use for inventing new technologies. Hamberg (1964) affirms that the scale of research and development activity, as well as the number of workers employed in R&D department grows along with the size of company (measured by employment level). In majority of industries, the revenue growth rate of 1% was accompanied with over-proportional increase in expenditures on basic research i.e. 1.65% (Mansfield,1981). However, Scherer (1965) points out that this relation is under-proportional. In contrast, results of research provided by Howe and McFetridge (1976) indicate that the relation between the firm size and expenditures on R&D activity is insignificant for mechanical industry, while in chemical industry for foreign firms it is different than for domestic enterprises (significant positive link).

Larger companies tend to show higher innovative activity (Wilder and Stansell, 1974; Cohen and Klepper, 1996; Canto and Gonzalez, 1999; Cho, Lee, Kang and Kwon, 1999; Gustavsson and Poldahl, 2003; Lee and Hwang, 2003), especially in high-tech industry (Bhattacharya and Bloch, 2004). Hyeog and Tomohiki (2013) based on results from the study of 13,000 Japan companies from industrial sector, and Mansfeld (1981) based on the sample of about 100 companies from different sectors, prove that the relation between the size of an enterprise and the expenditures on R&D takes shape of reverse "U" letter. It means that expenditures initially increase along with the size of the company, and at some point they start to fall down. In the case of studies on new products and processes, it is noticeable that the relation between the size of an enterprise and expenditures on R&D is under-proportional – 1% to 0.78%. The results of Cohen, Levin and Mowery (1987) research indicate, that the type of industry is more important for carrying out R&D activity than the size of an enterprise. Acs and Audretsch (1987) confirm innovative advantage of larger companies over smaller ones among capital-intensive sectors and in strongly concentrated markets, using the number of registered innovations as a measure. However, among less capital-intensive sectors and in less concentrated markets smaller firms tend to display higher innovation level.

2.2. PROFITABILITY

In the companies performing worse than expected, the surplus of their resources increases the expenditure level on R&D activity. While in the companies performing better, the surplus of their resources has to be much higher for it to have positive impact on R&D expenditures (Ru-Chen and Miller, 2007). Malmberg (2008) shows positive influence of expected return on R&D expenditures, based on the sample of Swedish pharmacist companies in the period of 1960 – 1990. Ali-Yrkkö (2004) analyzing Finnish enterprises in high-tech industry, proves that the profit from a previous year has positive influence on the level of R&D expenditures in the given year. Branch (1974) and Roucan-Kane,

Ubilava and Xu (2007) observe positive relation between companies' profit and R&D expenditures. Howe and McFetridge (1976), Bhattacharya and Bloch (2004), Manganelli (2010) has not proven significant relation between profitability and R&D expenditures. Chen and Miller (2007) show that companies tend to spend less on R&D, when their profits exceed industry's average.

Manganelli (2010) proves that the lack of liquidity reduces the level of expenditures on R&D. Himmelberg and Petersen (1994) and Bloch (2005) indicate that cash flows have significant impact on R&D expenditures, Malmberg (2008) confirms only the impact of 2-year lagged cash flow, while Bhagat and Welch (1995) prove the negative impact of cash flows on R&D expenditures among companies from USA. Bond, Harhoff and Van Reenen (2005) show that operational cash flows have a positive impact on probability of R&D investment existence among British companies, while Mulkay, Hall and Mairesse (2001) receive the same results for American companies. Brown, Fazzari and Petersen (2009) observe in their results that there is a considerable impact of cash flows on R&D expenditures in the case of young American companies and a small impact in the case of large companies from high-tech sector. A positive impact of cash flows on R&D expenditures has been observed by Cleary (1999) for USA, Guariglia (2008) for United Kingdom and Grabowski i Vernon (2000) for 11 major drug firms. Brown and Peterson (2011) show positive relation between cash flows and R&D expenditures in a given year, where the biggest one is for young companies in the period of 1970-1981, while cash flows from previous year have negative impact on R&D expenditures. Armour and Teece (1981) observe positive impact of cash flows lagged by 1 year, 2 years and 3 years on R&D expenditures, while analyzing American companies from energy industry. The strongest impact is observed in case of cash flows lagged by 2 years. Hyeog and Tomohiko (2013) prove that enterprises' internal funds (savings) have positive impact on research and development expenditures. However, dividends' payment reduces cash holdings. Lee and Hwang (2003) prove that companies which pay higher dividends tend to lower their R&D expenditures. In contrast, due to results of Switzer (1984), Fazzari and Athey (1987), Cho et al. (1999) studies, dividends' payment has a positive influence on research and development expenditures.

2.3. GROWTH OPPORTUNITIES AND THE ROLE OF PATENTS

Cumming and MacIntosh (2000) prove that the availability of patent protection leads to higher R&D expenditures. Lee and Hwang (2003) and Guariglia (2008) prove that the higher the growth opportunities, the higher the expenditures on R&D investment. On the other hand, results received by Brown and Peterson (2011) are not explicit, but they indicate the negative relation between growth opportunities and R&D expenditures in the period of 1970-1981, especially for young companies; positive relation in the period of 1982-1993, either for young and mature companies, while in the period of 1994-2006 there is a negative relation in the case of young companies and positive relation in the case of mature companies.

2.4. FINANCING BY GRANTS AND CORPORATE INVESTMENTS IN R&D

Howe and McFetridge (1976) show that entities with domestic capital spend more on R&D than they obtain grants, contrarily to companies with foreign capital. In the case of German enterprises, Almus and Czarnitzki (2003) prove that R&D expenditures are, on average, 4% higher than the value of their grants obtained. Obtained grants encourage companies to increase their R&D expenditures (Carboni,

2011), in ICT sector (Lee and Hwang, 2003) and industrial sector (Becker and Pain, 2003). Results of Ali-Yrkkö (2004) study are consistent with findings mentioned above, as grants from previous year, as well as grants from a given year have positive impact on R&D expenditures in a given year. Dugueta (2004), as well as Czarnitzki and Hussinger (2004) confirm that subsidies strengthen the private expenditures on R&D and that the crowding-out effect does not take place. Ali-Yrkkö (2004) stresses that public R&D funding can be seen as lowering the private cost of an R&D project and making an unprofitable project profitable. If any R&D infrastructure is bought with an R&D subsidy, the fixed costs of other R&D projects are lowered. The know-how or knowledge developed in subsidized projects diffuse to other projects, improving their probability of success.

2.5. DEBT FINANCING

Enterprises with higher debt to equity ratio spend less on R&D (Cumming and MacIntosh, 2000). Bhagat and Welch (1995) indicate that debt ratio is negatively related with R&D expenditures among American companies, while in the case of Japan companies they observe positive relation. However, in the case of Canadian, British and European companies there is no relation between debt ratio and investment expenditures observed. The results of Bond, Harhoff and Van Reenen (2005) study show that high debt to equity ratio holds down enterprises, which are not investing in R&D, from making these kind of decisions in the next period. Brown and Petersen (2011) prove that issuing debt securities has positive impact on R&D expenditures, while the issue of debt securities in the previous year has negative impact.

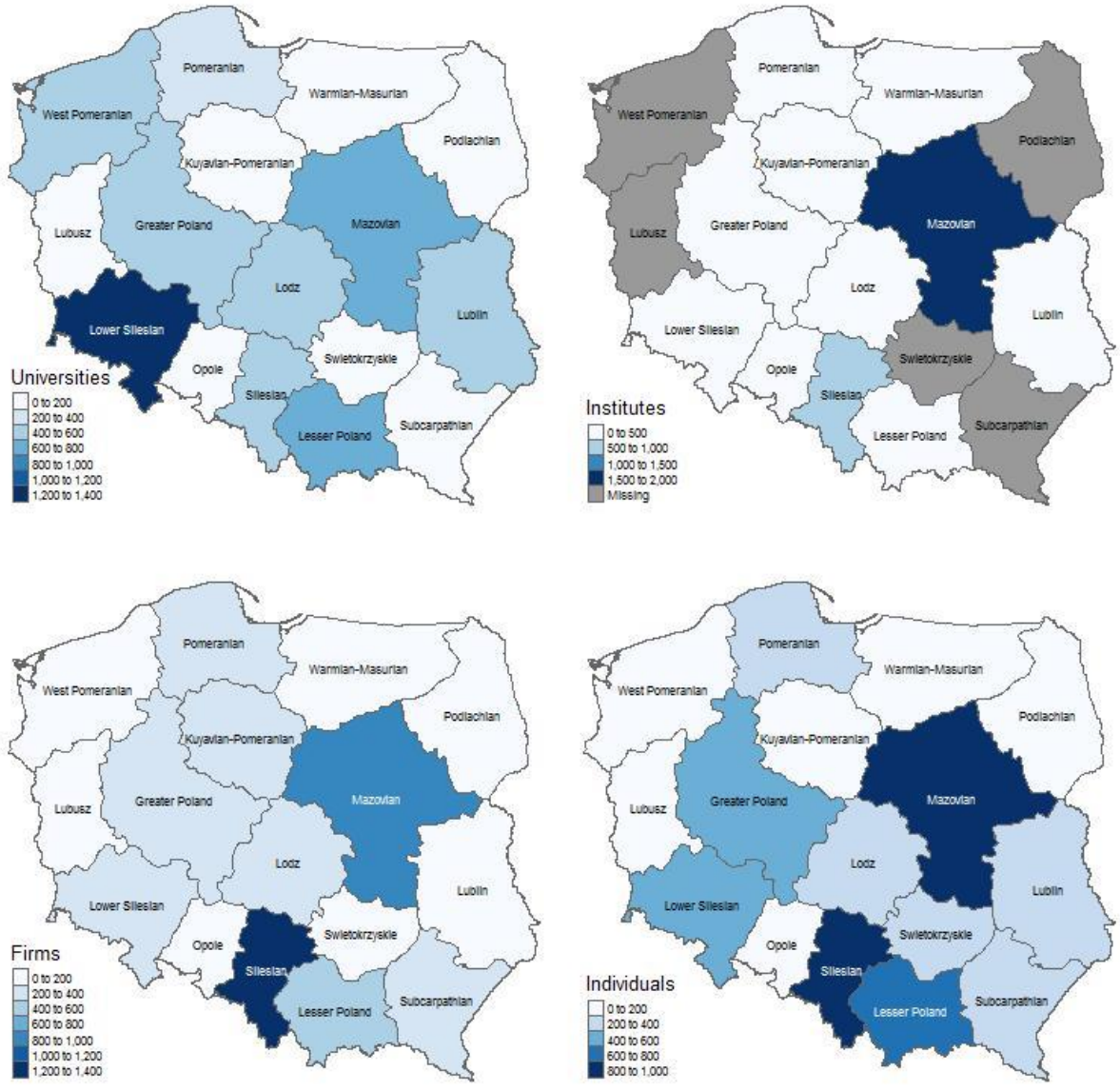
2.6. THE ROLE OF RESOURCES AND SCIENTISTS IN MANAGEMENT BOARD IN R&D ACTIVITY

Based on the results of a survey conducted in Poland in February/March 2015 Białek-Jaworska, Gabryelczyk and Pugacewicz (2015) show that companies using R&D in their business appreciate the significance of the founders' achievements (a "Star" scientist (Zucker and Darby, 1998), the board's managerial skills (Colombo and Grilli, 2005), patents (Shane, 2004; Niosi, 2003; Penin, 2005) and information technology. Among factors important for R&D cost reduction, they identify the business location and the proximity of university centers and the access to the science and research infrastructure (Zucker and Darby, 1998). Accessibility to sources of financing R&D activities is crucial (Lerner et al., 2003; Brown et al., 2009; Gorodnichenko and Schnitzer, 2010; Aghion et al., 2012) the more the R&D project risks depend on the effectiveness in applying for research grants (Almus and Czarnitzki, 2003; Becker and Pain, 2003; Lee and Hwang, 2003; Klette and Moen, 2012). Scientists' participation in the Supervisory Board may be helpful in associating specialist knowledge with the needs of companies' looking for solutions to the products/services developed themselves. The co-operation with partners may also help monetize those of the R&D results that have not been used internally (Białek-Jaworska, Gabryelczyk and Pugacewicz, 2015).

3. SPATIAL STATISTICS' ANALYSIS OF PATENTS IN POLAND

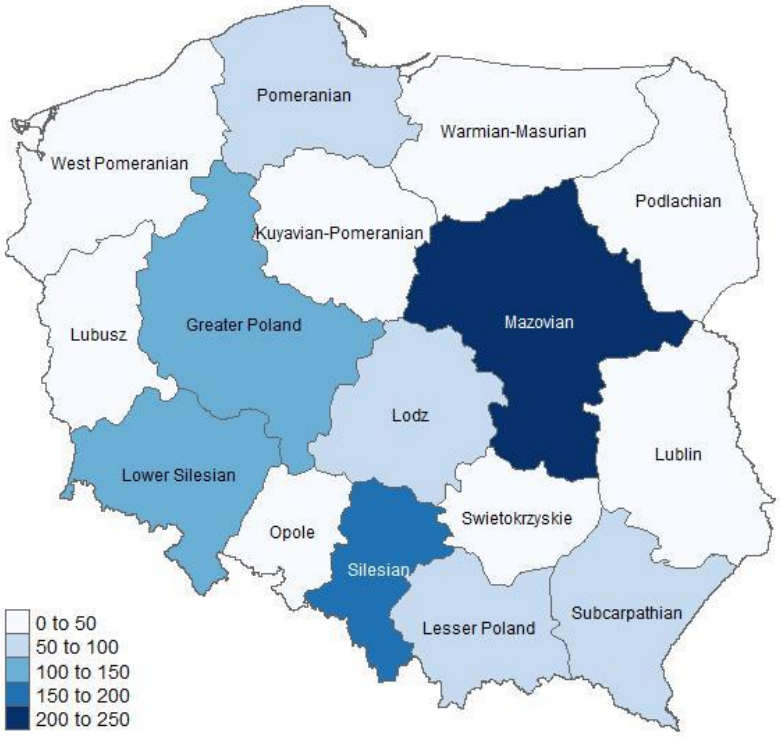
We observe the high diversity of research activity in Poland. The spatial statistics of patents sheds some light on structural differences between Polish regions. Figure 1 presents the total number of patents based on the data from the Polish Patent Office separately for universities, institutes, firms and individuals.

Figure 1. Total number of patents registered in Polish Patent Office in years 2008-2015



The highest number of patents is registered by universities of the Lower Silesian voivodeship, which is due to active cooperation by academic centers with international KGHM concern (mostly with its affiliate limited liability company KGHM CUPRUM – R&D Centre). The other important entity, maybe even more impactful than KGHM, in the Lower Silesian voivodeship is limited liability company EIT+ Wrocław Research Centre. It is the first RTO (Research and Technology Organization) in Poland, focused on the development of innovations, new technologies and studies for the needs of the modern industry. Their activity involves, inter alia, 59 research projects, 48 patent applications (Polish and PCT) and 14 spin-off companies created. The other most active academic centers in Poland, in terms of registering patents, are Lodz (with the third highest average number of patents per university – dominant role of Lodz University of Technology, but with relatively low number of universities registering patents and low competition among research institutes), Mazovian and Lesser Poland voivodeships (dominant role of AGH University of Science and Technology). In Mazovian voivodeship, the biggest role in registering patents is played by universities (mainly Warsaw University of Technology), research institutes (like Industrial Research Institute for Automation and Measurements, Industrial Chemistry Research Institute or Tele & Radio Research Institute) and individuals (mainly scientists collecting points for registered patents for the needs of interim evaluations of academic staff). Often, patents are the basis for the settlement of projects co-financed by grants, which positively influences the activity among research institutes. Voivodeships with relatively higher number of scientists being more active in registering patents are, besides Mazovian voivodeship, Silesian, Lesser Poland and Greater Poland. However, in the case of business sector the highest number of patents is registered by companies placed in Silesian voivodeship. It may be due to high R&D activity by industrial and mining-and-steel sectors, but also due to the lower activity of universities and research institutes.

Figure 2. The number of companies in the sample



In Silesian voivodeship patents are registered rather by individuals, similarly to Lesser Poland (that is a seat for Jagiellonian Life Science cluster). It indicates ineffective cooperation between science and business in the field of R&D activity strengthened with registered patents. It seems that in Mazovian voivodeship (with the capital of Poland and headquarter of the National Centre for Research and Development) patents are the main basis for settlement of research grants obtained by universities and research centers and for the researchers' assessment and promotions. On the contrary, in Silesian voivodeship, the most industrialized Polish region, patents are registered mainly by individuals (including scientists from universities of technology and medical universities) and companies, not by academic or research centers. High industrialization enhances the knowledge and innovations' flow to the business sector. Similarly, we can see that low competition among research institutes in terms of obtaining research grants and registering patents favors the development of registering patents based on the outcomes of R&D activity among companies. In the analyzed sample, the highest number of companies commercializing R&D outcomes (capitalizing R&D expenditures in the balance sheet) are placed in Mazovian, Silesian, Lower Silesian and Greater Poland voivodeships (see Figure 2).

4. HYPOTHESES

Based on the literature review we stated the following hypotheses:

H1: The ability to self-financing, measured by relation of cash flow from operational activity to assets, positively influences the R&D expenses that are capitalized in the balance sheet, especially in the case of academic entrepreneurship (firms managed by scientists).

H2: Larger companies spend more money on R&D outcomes recorded in the balance sheet.

Additionally, we suppose that **(H3)** companies' growth opportunities negatively influence academic entrepreneurship' expenses on the R&D activity, and that **(H4)** higher operational risk limits expenditure on R&D.

5. RESEARCH SAMPLE AND DEFINITIONS OF VARIABLES

In order to identify what determines decisions made by management concerning commercialization of the results from research and development activity measured by the level of expenses on development works recognized as an asset in the balance sheet, we use data retrieved from financial statements of private nonfinancial capital companies. The data base used for analysis contains 23,667

non-public limited liability and joint-stock companies' financial statements for the period of 2003-2013 (235,046 firm-year observations). However after inclusion in our analysis of lagged explained variable (rdexpen_lag) and other explanatory variables based on data from financial statements, defined in the Table 1, our research sample was limited to 108,773 firm-year observation of 22,633 private companies. Among the determinants of R&D activities we consider the following factors: ability to self-financing (measured by cash flow from operating activity), firm cash holdings, debt, capital structure, firm size (measured by total sales), growth opportunity (measured by growth rate of total sales) and operational risk. The following Table 1 presents a complete description of variables used in the empirical analysis. Before a probit panel analysis, the descriptive statistics of variables has been determined (Table 2) and the correlation between explanatory variables has been estimated. Detailed outcomes of correlation of the explanatory variables are presented in Tables 5-8 in the appendix. Additionally, we present the descriptive statistics of variables used in probit panel models for companies conducting R&D activity (Table 9), managed (Table 10) and supervised by scientists (Table 11) in the appendix.

Table 1. Definitions of variables used in the probit panel analysis on the total sample

Variable	Definition of variable
rdexpen	development costs capitalized in the balance sheet (as percentage of assets)
AM academics in management board	dummy variable that takes the value of 1 if in the board sit scientists (variable determined on the basis of linkage of database of the National Court Register and database of scientists), and 0 otherwise
AS academics in supervisory board	dummy variable that takes the value of 1 if in the board of directors (supervisory board) sit scientists (variable determined on the basis of linkage of database of the National Court Register and database of scientists), and 0 otherwise
cash flow/assets	self-financing as percentage of assets = cash flow from operations / assets
cash holdings	corporate cash resources measured by the share of cash and short-term financial assets in assets
debt	debt = long-term liabilities and short-term liabilities resulted from loans and borrowings, issue of debt securities and other financial liabilities to other entities / total assets
leverage	total long-term liabilities and total short-term liabilities / (total assets - capital from revaluation)
d6	leverage with trade credit = total liabilities without payables to related parties, excluding liabilities for taxes, wages and to employees and prepayments for delivery / total assets
d6_2	leverage without trade credit = total liabilities without trade credit, excluding liabilities for taxes, wages and to employees and prepayments for delivery / total assets
loans	bank and other loans borrowed, based on cash flow statement or change of liabilities
size_income	company size measured by the natural logarithm of sales volume
growth	growth opportunities, measured by the growth rate of sales revenue year to year
risk_oper	threat of operational risk = standard deviation of cash flow from operations for the last three years of cash flow from operating activities / total assets
share_issue_flag	dummy variable that takes the value of 1 if a company issues shares, i.e. if share capital in t year - share capital in t-1 year >0, and 0 otherwise
grants_profit&loss	grants recognized in the income statement
grants_scaled	grants recognized in the income statement / total assets
grants_balance_ share	subsidies for fixed assets and intangible assets recognized in the liabilities in the balance sheet as value of long-term other deferred income / total assets

Table 2. Descriptive statistics of variables used in the probit panel analysis on the total sample

Variable	Obs	Mean	Std. Dev.	Min	Max
subj_id	235046	1730632	639970.9	1986	1.04e+07
year	235046	2008.783	2.89422	2003	2013
rdexpen	210022	0.0024926	0.0622278	0	23.91163
rdexpen_lag	188364	0.0023798	0.0640914	0	23.91163
rdexpen_lag2	188364	0.0041134	1.317629	0	571.7661
R&D	235046	0.0465271	0.210624	0	1
AM	235046	0.1541315	0.3610756	0	1
AS	235046	0.0739728	0.2617271	0	1
cash flow/assets	153644	0.5757902	167.1166	-14818.45	48011.46
cash flow/assets_lag	128768	0.7692325	183.5575	-14818.45	48011.46
cash holdings	234026	0.1884487	0.2547636	0	32.00077
debt	234025	1.232432	169.861	0	47145.06
leverage	234071	8.98856	2227.889	0	1048921
d6	234049	6.165349	1492.188	-3.770384	689571.5
d6_2	234049	3.207067	446.5023	-3.781753	123273.4
size_income	219838	14.99437	2.308021	-1.469676	23.69622
growth	196769	17.29839	1875.578	0	529349.8
risk_oper	204256	11.2881	2220.482	0	915190.3
share_issue_flag	235046	0.0827966	.2755751	0	1
loans	217670	240811.9	1.18e+07	-7.25e+08	4.57e+09
grants_profit&loss	234468	111251.2	5268090	0	9.72e+08
grants_scaled	234067	0.0133621	0.4025126	0	100.1468
grants_balance_share	234070	0.0133514	0.3822319	0	92.78541

6. RESULTS

In our study we used functional form of the model proposed by Brown, Fazzari and Petersen (2009) with the lagged spending on R&D variable and squared lagged spending on R&D. Due to the low level of expenditure on R&D (developmental works) capitalized in the balance sheet, we decided to scale it by fixed assets. However, a high number of zero observations (mean 0.0024926) resulted in our choice of estimation methods - panel probit analysis. The coefficient of the lagged variable of expenditure on R&D is positive, and the lagged variable expenditure on R&D raised to the square is negative, which is consistent with the results of Brown, Fazzari and Petersen (2009), Brown and Petersen (2011) and Nehrebecka and Białek-Jaworska (2015). The results indicate, that if the company pursued development in a given year, it is likely to have decided to continue spending on R&D in the following periods (the rdexpen_lag and rdexpen_lag2 variables). The presence of scientists in the board of directors is typical for the company that recognizes higher expenditure on commercialized results of R&D activity in the form of completed developmental works (in the balance sheet) (Table 3), also in companies managed by scientists (Table 4). On the contrary, the companies managed by scientists show lower expenditure on R&D, but the variable is significant only in the model for the total sample. The positive impact of cash flow from operational activity / assets on expenditures on R&D capitalized in the balance sheet in the development enterprises (that conduct R&D activity) and in those managed by scientists indicates, that a higher capacity for self-financing supports the development of R&D activity. This indicates that there is no basis to reject the hypothesis H1. The results are consistent with the conclusions of Himmelberg and Petersen (1994), Grabowski and Vernon (2000), Mulkay, Hall and Mairesse (2001), Bloch (2005), Bond, Harhoff and Van Reenen (2005), Guariglia (2008) and Brown and

Peterson (2011). The decrease in corporate cash holdings determines significant expenditures on R&D, which results from the financing this business by cash resources because of the accompanying high risk. Similar conclusions were drawn by Brown, Martinsson and Petersen (2012). Larger enterprises face higher expenditures on research and development, that is in accordance with H2. Higher spending on R&D is accompanied by lower financial leverage and the d6 leverage variable, including a non-commercial short-term liabilities to related parties and trade credit received from other entities. Companies conducting R&D activity increase spending on R&D by debt financing, while firms supervised by scientists show lower debt due to loans and borrowings, issue of corporate bonds and other financial liabilities (the debt variable). This may be due to the lower use of trade credit (or faster repayment it with use of subsidies received) by enterprises conducting R&D activity. This effect is stronger (the higher the absolute value of the coefficients using the d6 variable) in academic enterprises AM. Academic enterprises (AM and AS) that have lower growth opportunities tend to increase spending on R&D (Table 4). It may be due to the instability of revenue from sales and problems with sales channels. This indicates that there is no basis to reject the hypothesis H3. In other models for the total sample and development companies the growth variable was not significant (Table 3). The reason may also be a lack of experience in running a business - the commercialization of research results without the proper identification of customer segments or/and building relationships with customers. The results indicate a strong positive relationship between effects of the R&D activity conducted by non-academic companies and enterprises supervised by scientists (AS) and obtaining grants both recognized in the income statement, as well as recognized in the balance sheet (for the construction or purchase of fixed assets or intangible assets). Grants recognized in other operating income (in profit & loss statement) may also be a part of grants recognized in the balance statement to be settled parallel to the depreciation of fixed assets or intangible assets financed with the grants. In the case of companies managed by scientists (AM), grants for infrastructure (shown in the balance sheet and deferred in the wake of the gradual consumption financed fixed or intangible assets) are the only important ones. Higher spending on R&D is accompanied by a decision to issue shares or increasing the share capital in the limited liabilities company (Table 3 - total sample and Table 4 - AM), especially in companies managed by scientists. This indicates the importance of the stock exchange (the share_issue_flag variable) in financing risky and capital-intensive R&D activity. Białek-Jaworska and Gabryelczyk (2015) indicate the importance of the funding by share issue on the NewConnect (the alternative market of the Warsaw Stock Exchange), especially for biotech start-ups R&D activity. Higher operational risk limits expenditure on R&D activity (Table 3), according to the assumptions formulated in the hypothesis H4. However, in the case of academic entrepreneurship the risk_oper variable's effect is less significant (15% in the AS firms and 20% in the AM firms) (Table 4). This may be due to the relatively higher operational risk related to the R&D activity conducted by young, small and unstable academic enterprises.

7. CONCLUSIONS, DISCUSSION AND DIRECTIONS OF FUTURE RESEARCH

Due to our study, we found that the effects of commercialization of the R&D activity's outcomes positively depend on the ability to self-financing (H1). The relationship between cash flow and spending on the R&D activity was confirmed by Bloch (2005), Bond, Harhoff and Van Reenen (2005), Guariglia (2008), as well as Brown and Peterson (2011). Larger companies spend more money on R&D outcomes recorded in the balance sheet (H2). Similar findings were received by Acs and Audretsch (1987), Gustavsson and Poldahl (2003), Lee and Hwang (2003) and Bhattacharya and Bloch (2004). Important sources of financing R&D activities are corporate cash holdings (also pointed by Hyeog and Tomohiko, 2013), debt from loans and borrowings, issue of corporate bonds (Brown and Petersen, 2011) and other financial liabilities (except for enterprises supervised by scientists), grants for research and infrastructure (in accordance with Carboni (2011) and Ali-Yrkkö (2004)), the proceeds of the share issue (especially in academic enterprises AM). In the case of academic entrepreneurship, managed by scientists, only subsidies for tangible and/or intangible assets (R&D outcomes) play a significant role. Academic entrepreneurship (with scientists in the management board and/or the board of directors) with lower growth opportunities increase spending on R&D related to the commercialization of research outcomes (H3). Probably this is due to their lower experience in conducting business activities and the commercialization of R&D results, lack of formulating proposals for the identified customer segments or lack of building relations with customers. Brown and Peterson (2011) observed that this relationship was negative mainly for young firms. Additionally, based on our findings positively verifying the H4, it should be emphasized that the higher operational risk limits expenditure on the commercialization of R&D activities. Future research could be concentrated on an inclusion of the impact of patents and cooperation with universities in research projects financed by research grants. However, extension of the research requires linking the database of patents gained from the Polish Patent Office with data retrieved from financial statements of private nonfinancial companies as well as collected data of scientific alliances and partnerships in research project realization.

Table 3. Results of the probit panel models on determinants of expenses for R&D activity

Random-effects probit regression u_i ~ Gaussian Integration method: mvaghermite Integration points 12						
Number of obs	108773	104485	108773	4914	4695	4914
No. of groups	22633	22535	22633	844	844	844
Obs per group: min	1	1	1	1	1	1
avg	4.8	4.6	4.8	5.8	5.6	5.8
max	9	9	9	9	9	9
	total sample	total sample	total sample	R&D	R&D	R&D
rdexpen_lag	18.19354***	19.75474***	18.18354***	11.95095***	12.05159***	11.88916***
	(0.7986364)	(0.7794952)	(0.7988704)	(0.6175832)	(0.632064)	(0.6170756)
rdexpen_lag2	-17.10198***	-18.49157***	-17.08394***	-11.43839***	-11.51162***	-11.38833***
	(0.980384)	(0.9571193)	(0.9807475)	(0.7622556)	(0.7767517)	(0.7621043)
cash holdings	-1.069525***	-1.037283***	-0.996523***	-1.187629***	-1.222539***	-1.125605***
	(0.2083763)	(0.1894127)	(0.2068721)	(0.2217574)	(0.228504)	(0.2199663)
debt	0.0886248	0.1305712		0.2815594##	0.3551941*	
	(0.1756662)	(0.1612097)		(0.1790743)	(0.1937837)	
leverage			-0.1425088**			-0.202413***
			(0.0743994)			(0.0707838)
d6	-0.2954501**	-0.370535***		-0.338853***	-0.384625***	
	(0.1270437)	(0.1180741)		(0.113222)	(0.1212351)	
d6_2			-0.1300332			
			(0.1317875)			
loans		-2.48e-11			-4.27e-10	
		(1.24e-09)			(1.34e-09)	
size_income	0.3596048***	0.300819***	0.3634496***	0.089588***	0.087976***	0.0954795***
	(0.0218649)	(0.0189308)	(0.0217632)	(0.0203237)	(0.0208873)	(0.0201905)
growth	-0.0003968	-0.0001508	-0.0004592	0.0033061	0.0094348##	0.0023798
	(0.0013173)	(0.0006165)	(0.0014338)	(0.0037997)	(0.0059496)	(0.0037549)
risk_oper	-0.0974692	-0.2368631**	-0.0595782	-0.1057866	-0.324339***	-0.0646552
	(0.0903531)	(0.1094707)	(0.0877339)	(0.093831)	(0.1261819)	(0.0931064)
share_issue_flag	0.1686096**	0.1717954**	0.1661339**	0.0947068	0.1132216#	0.0874862
	(0.0759413)	(0.0708277)	(0.0759076)	(0.0811439)	(0.0837138)	(0.081162)
cash flow/assets	0.0357489	0.0779219**	0.0238019	0.486409***	0.521779***	0.4518303***
	(0.02891)	(0.0346263)	(0.0281521)	(0.1048095)	(0.1108794)	(0.1058919)
cash flow/assets _lag	-0.0074355	-0.0068412	-0.0063202	-0.0515467	-0.0354718	-0.0723432
	(0.0142416)	(0.0202526)	(0.0127536)	(0.1038583)	(0.1078828)	(0.1037493)
grants_balance _share			2.165072***			1.756907***
			(0.294447)			(0.3955512)
grants_profit & loss	3.64e-09*			4.50e-09##		
	(2.28e-09)			(3.16e-09)		
grants_scaled		0.11945#			0.4823957#	
		(0.0941878)			(0.380649)	
academics in management	-0.1765737*	-0.1607112*	-0.1837284*	-0.1004343	-0.1158217	-0.1204631
	(0.1097812)	(0.088404)	(0.1095145)	(0.1057698)	(0.1076495)	(0.1055591)
academics in supervisory board	0.2824853**	0.2216321**	0.2773786**	0.2075302*	0.2003034##	0.2008585*
	(0.1352922)	(0.1030758)	(0.1346142)	(0.1245624)	(0.126734)	(0.1241404)
_cons	-10.80692***	-8.916393***	-10.87337***	-2.005646***	-1.95454***	-2.129342***
	(0.389866)	(0.3534914)	(0.3924994)	(0.3534997)	(0.3650992)	(0.3518071)
/lnsig2u	1.48067	0.9489475	1.454192	-0.4032212	-0.3879682	-0.4162071
	(0.0567317)	(0.0513203)	(0.0594175)	(0.1067549)	(0.1084823)	(0.1070509)
sigma_u	2.096637	1.607168	2.069063	0.8174132	0.823671	0.8121229
	(0.0594729)	(0.0412401)	(0.0614692)	(0.0436314)	(0.0446769)	(0.0434692)
rho	0.8146737	0.7209035	0.8106427	0.4005387	0.4042065	0.3974247
	(0.0085654)	(0.0103257)	(0.0091206)	(0.0256326)	(0.0261251)	(0.0256364)
Wald chi2(10)	1017.10	1215.84	1062.48	518.04	507.62	531.64
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-4490.1876	-4320.0259	-4468.3766	-2482.2073	-2365.9792	-2473.1483
Likelihood-ratio test of rho=0:						
chibar2(01)	3063.11	2846.39	3034.45	408.15	388.77	400.73
Prob >= chibar2	0.000	0.000	0.000	0.000	0.000	0.000

Significant at 20%, ## Significant at 15%, * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 4. Results of the probit panel models on determinants of expenses for R&D activity

Random-effects probit regression u_i ~ Gaussian Integration method: mvaghermite					
Number of obs	752	722	752	11641	8622
Number of groups	127	127	127	1551	1509
Obs per group: min	1	1	1	1	1
avg	5.9	5.7	5.9	7.5	5.7
max	9	9	9	11	9
Integration points	12	12	12	12	12
	AM	AM	AM	AS	AS
rdexpen_lag	11.27915***	11.62281***	11.56674***	24.99608***	25.11896***
	(1.709694)	(1.767834)	(1.718553)	(2.257264)	(2.589025)
rdexpen_lag2	-10.58559***	-10.9649***	-11.12742***	-26.38818***	-26.61855***
	(2.384983)	(2.49818)	(2.410267)	(3.103604)	(3.433762)
cash holdings	-1.277519*	-1.535583**	-1.174424*	-0.5465277#	-1.472927**
	(0.7145766)	(0.7674546)	(0.7077751)	(0.4924709)	(0.6770182)
debt	0.3637095	0.443441		-0.9841246**	
	(0.6592295)	(0.7087919)		(0.4221325)	
leverage			-0.2681538		-1.257212***
			(0.398006)		(0.3923729)
d6	-0.6486608#	-1.004731*			
	(0.5154639)	(0.5585579)			
d6_2			-0.167813		
			(0.5561814)		
loans		8.26e-09##			
		(5.21e-09)			
size_income	0.1851985***	0.170236***	0.182735***	0.2019251***	0.2540088***
	(0.0610668)	(0.0625476)	(0.0590715)	(0.0523641)	(0.0656851)
growth	-0.4336011**	-0.4687474**	-0.446376**	-0.1474977	-0.467788**
	(0.1882111)	(0.1999728)	(0.1886668)	(0.1289214)	(0.1867236)
risk_oper	-0.3982512#	-0.4298525#	-0.341625	-0.4975154##	-0.0656751
	(0.3117535)	(0.3472825)	(0.3195764)	(0.3441058)	(0.2944487)
share_issue_flag	0.3288296##	0.328722#	0.2985416#	0.0553652	0.1274823
	(0.222785)	(0.236667)	(0.2244337)	(0.1715478)	(0.2157372)
cash flow/assets	0.7763417**	0.7394693**	0.7073781**		0.2437536
	(0.3211216)	(0.380144)	(0.3255995)		(0.2105594)
cash flow/assets_lag	0.3723757	0.3515127	0.3410043		-0.0797237
	(0.306201)	(0.3226206)	(0.2985206)		(0.2381029)
grants_balance_share			1.927614**		1.78256*
			(0.8861917)		(1.045306)
grants_pl	-4.26e-08			6.67e-08*	
	(5.52e-08)			(3.73e-08)	
grants_scaled		0.4829646			
		(1.664646)			
academics in supervisory	0.6053793**	0.6914964**	0.621634**		
board	(0.3103427)	(0.3216716)	(0.3033308)		
_cons	-3.207634***	-2.845238***	-3.252109***	-6.953558***	-7.079625***
	(1.029999)	(1.055293)	(1.004679)	(0.9398113)	(1.263045)
/lnsig2u	-0.0780601	-0.0075139	-0.1598854	0.9539542	0.9459856
	(0.2855016)	(0.2890054)	(0.2884712)	(0.1368523)	(0.2937384)
sigma_u	0.9617218	0.9962501	0.9231692	1.611197	1.60479
	(0.1372866)	(0.1439608)	(0.1331539)	(0.110248)	(0.2356942)
rho	0.4804949	0.4981215	0.4601136	0.7219097	0.7203071
	(0.0712668)	(0.0722503)	(0.0716589)	(0.0274739)	(0.0591779)
Wald chi2(10)	89.88	89.78	94.21	163.11	139.49
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	-340.33724	-321.56676	-338.44578	-604.94906	-468.08594
Likelihood-ratio test of rho=0:					
chibar2(01)	67.98	67.29	63.36	465.21	269.29
Prob >= chibar2	0.000	0.000	0.000	0.000	0.000

Significant at 20%, ## Significant at 15%, * Significant at 10%, ** Significant at 5%, *** Significant at 1%.

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Table 5. The correlation matrix of explanatory variables used in the probit panel analysis on the total sample

	rdexp _lag	rdexp lag2	cash holdin	debt	lever	d6	d6_2	size_ income	growth	risk oper	share flag	cashflow /assets	cashflow /assets lag	loans	grants scaled	grants balanc share	grants pl	am	as
rdexpen_lag	1.0000																		
rdexpen_lag2	0.9187	1.0000																	
cash holdings	0.0006	0.0053	1.0000																
debt	-0.0002	-0.0001	0.0010	1.0000															
leverage	-0.0001	-0.0000	0.0187	0.1418	1.0000														
d6	-0.0002	-0.0000	0.0372	0.3832	0.1476	1.0000													
d6_2	-0.0002	-0.0001	0.0113	0.3860	0.1431	0.9916	1.0000												
size_income	0.0045	-0.0011	-0.1817	-0.0234	-0.0119	-0.0204	-0.0196	1.0000											
growth	-0.0004	-0.0001	-0.0058	0.0004	-0.0000	0.0003	0.0003	0.0033	1.0000										
risk_oper	-0.0002	-0.0000	0.0161	0.1299	0.9906	0.0847	0.0818	-0.0140	-0.0000	1.0000									
share_flag	0.0046	-0.0007	-0.0505	-0.0014	-0.0013	-0.0018	-0.0015	0.0613	0.0136	-0.0006	1.0000								
cashflow /assets	-0.0001	-0.0000	0.0108	0.0921	0.9755	0.0464	0.0440	-0.0071	-0.0000	0.9656	-0.0010	1.0000							
cashflow /assets_lag	0.0006	-0.0000	0.0042	0.1364	0.0091	0.0530	0.0540	0.0106	-0.0012	0.0011	0.0011	0.0013	1.0000						
loans	-0.0006	-0.0001	-0.0140	0.0026	-0.0001	0.0007	0.0008	0.0387	0.0051	-0.0005	0.0288	0.0001	-0.0041	1.0000					
grants_ scaled	0.0014	-0.0000	0.0265	0.0523	0.0038	0.0266	0.0201	-0.0230	-0.0004	0.0042	-0.0027	-0.0011	0.0002	-0.0011	1.0000				
grants bal_share	0.0120	-0.0003	-0.0600	-0.0011	-0.0007	0.0004	-0.0013	0.0144	-0.0002	-0.0011	0.0363	-0.0005	0.0022	0.0136	0.0074	1.0000			
grants_pl	0.0002	-0.0001	-0.0061	-0.0002	-0.0001	-0.0001	-0.0002	0.0380	-0.0001	-0.0001	0.0112	-0.0001	-0.0004	0.0394	0.0278	0.0349	1.0000		
am	-0.0022	-0.0014	-0.0158	-0.0027	-0.0021	-0.0032	-0.0027	0.0290	-0.0033	-0.0023	0.0053	-0.0015	0.0000	0.0059	0.0001	0.0049	-0.0042	1.0000	
as	0.0034	-0.0008	-0.0207	-0.0023	-0.0012	-0.0024	-0.0019	0.0628	0.0016	-0.0017	0.0074	-0.0008	0.0017	0.0006	-0.0010	0.0114	-0.0017	0.0940	1.0000

Table 6. The correlation matrix of explanatory variables used in the probit panel analysis on the sample of firms conducting R&D activity

	rdexp_lag	rdexp lag2	cash holdin	debt	lever	d6	d6_2	size_ income	growth	risk oper	share flag	cashflow /assets	cashflow /assets lag	loans	grants scaled	grants balanc share	grants pl	am	as
rdexpen_lag	1.0000																		
rdexpen_lag2	0.9254	1.0000																	
cash holdings	0.0470	0.0422	1.0000																
debt	0.0092	-0.0044	-0.1071	1.0000															
leverage	0.0128	-0.0032	-0.1150	0.7701	1.0000														
d6	0.0142	-0.0015	-0.1424	0.8310	0.9589	1.0000													
d6_2	0.0121	-0.0051	-0.1137	0.9137	0.8632	0.9273	1.0000												
size_income	-0.0937	-0.0204	-0.1690	-0.0519	-0.0505	-0.0356	-0.0425	1.0000											
growth	-0.0048	-0.0012	-0.0017	0.0026	-0.0005	0.0011	0.0010	-0.0331	1.0000										
risk_oper	0.0032	-0.0008	0.0325	0.0707	0.1280	0.1269	0.1276	-0.1185	0.0015	1.0000									
share_flag	0.0040	-0.0046	-0.0295	0.0058	-0.0105	-0.0068	0.0005	-0.0049	0.0253	-0.0015	1.0000								
cashflow /assets	0.0009	-0.0004	0.0152	0.0112	0.0086	0.0096	0.0081	0.0628	-0.0008	-0.9233	-0.0023	1.0000							
cashflow /assets_lag	0.0254	-0.0049	0.0634	0.1089	0.0635	0.0688	0.0774	0.0588	-0.0358	-0.0136	-0.0492	0.0092	1.0000						
loans	-0.0046	-0.0007	-0.0203	0.0167	-0.0009	0.0055	0.0132	0.0632	-0.0006	-0.0042	0.0481	0.0004	0.0010	1.0000					
grants_ scaled	0.0357	-0.0004	0.0092	0.0557	0.0497	0.0389	0.0434	-0.1153	-0.0014	0.0260	0.0334	-0.0044	0.0126	-0.0035	1.0000				
grants bal_share	0.0267	-0.0043	-0.0826	0.0058	-0.0357	-0.0229	-0.0125	-0.0517	0.0074	-0.0123	0.0488	0.0071	0.0390	0.0519	0.0447	1.0000			
grants_pl	-0.0047	-0.0009	-0.0183	0.0120	-0.0045	-0.0020	0.0088	0.1041	-0.0024	-0.0051	0.0946	0.0006	-0.0046	0.2848	0.0223	0.0862	1.0000		
am	-0.0070	-0.0063	-0.0168	-0.0056	-0.0064	-0.0034	0.0016	-0.0380	-0.0029	0.0519	-0.0057	-0.0338	0.0016	0.0023	-0.0190	0.0442	-0.0121	1.0000	
as	0.0032	-0.0049	-0.0113	-0.0243	-0.0402	-0.0477	-0.0224	-0.0153	-0.0133	-0.0061	0.0232	0.0034	-0.0206	-0.0119	0.0218	0.0395	-0.0056	0.0749	1.0000

Table 7. The correlation matrix of explanatory variables used in the probit panel analysis on the sample of firms conducting R&D activity managed by academics

	rdexp _lag	rdexp lag2	cash holdin	debt	lever	d6	d6_2	size_ income	growth	risk oper	share flag	cashflow /assets	cashflow /assets lag	loans	grants scaled	grants balanc share	grants pl	as
rdexpen_lag	1.0000																	
rdexpen_lag2	0.9407	1.0000																
cash holdings	-0.0292	-0.0100	1.0000															
debt	0.0246	-0.0020	-0.3550	1.0000														
leverage	-0.0136	-0.0447	-0.2197	0.4214	1.0000													
d6	-0.0109	-0.0388	-0.2229	0.5236	0.9098	1.0000												
d6_2	-0.0144	-0.0267	-0.1621	0.5529	0.7870	0.8860	1.0000											
size_income	-0.1622	-0.1755	-0.1856	0.0678	-0.0003	-0.0015	-0.0202	1.0000										
growth	-0.0226	-0.0164	-0.0287	-0.0035	0.0309	0.0432	-0.0004	-0.0468	1.0000									
risk_oper	-0.0073	0.0014	0.0370	-0.0443	0.1421	0.1631	0.1992	-0.1846	-0.0003	1.0000								
share_flag	0.0268	0.0117	-0.0177	0.0171	-0.0317	-0.0050	-0.0086	-0.0024	0.0022	-0.0114	1.0000							
cashflow /assets	0.0102	0.0063	0.0152	0.0301	0.0192	0.0189	0.0043	0.1436	0.0018	-0.9477	0.0109	1.0000						
cashflow /assets_lag	0.1462	0.1917	0.0829	0.0880	-0.0725	-0.0415	-0.0363	-0.0397	0.0299	-0.0279	-0.0108	0.0116	1.0000					
loans	-0.0112	-0.0099	-0.0110	0.0758	0.0080	0.0214	0.0373	0.0827	-0.0017	-0.0047	0.0330	0.0015	0.0100	1.0000				
grants_ scaled	0.2840	0.3346	-0.0269	0.0626	-0.0164	-0.0017	0.0204	-0.1454	-0.0074	0.0159	-0.0032	0.0071	0.3237	-0.0108	1.0000			
grants bal_share	0.1399	0.1689	-0.0558	0.0292	-0.0032	-0.0119	-0.0253	-0.0440	-0.0170	-0.0184	0.1043	0.0155	0.1041	-0.0085	0.2734	1.0000		
grants_pl	-0.0246	-0.0186	-0.0247	0.0625	-0.0325	-0.0094	0.0300	0.2116	-0.0062	-0.0111	0.0558	0.0059	0.0187	0.0802	0.0456	0.2570	1.0000	
as	-0.0140	-0.0318	0.0442	0.0386	-0.0244	-0.0209	0.0385	-0.0913	-0.0017	-0.0101	0.0548	0.0146	-0.0796	-0.0203	-0.0415	-0.0434	-0.0225	1.0000

Table 8. The correlation matrix of explanatory variables used in the probit panel analysis on a sample of firms supervised by academics

	rdexp _lag	rdexp lag2	cash holdin	debt	lever	d6	d6_2	size_ income	growth	risk oper	share flag	cashflow /assets	cashflow /assets lag	loans	grants scaled	grants balanc share	grants pl
rdexpen_lag	1.0000																
rdexpen_lag2	0.9311	1.0000															
cash holdings	-0.0336	-0.0260	1.0000														
debt	-0.0057	-0.0046	-0.0444	1.0000													
leverage	-0.0026	-0.0016	0.0107	0.2343	1.0000												
d6	-0.0090	-0.0050	-0.0552	0.8203	0.3353	1.0000											
d6_2	-0.0036	-0.0012	-0.0318	0.8516	0.3236	0.9610	1.0000										
size_income	-0.0060	-0.0158	-0.1694	-0.0602	-0.0611	-0.0630	-0.0696	1.0000									
growth	-0.0011	-0.0007	-0.0090	-0.0035	0.0001	0.0037	0.0059	0.0060	1.0000								
risk_oper	0.0003	0.0016	0.0325	0.0954	0.2761	0.1973	0.1865	-0.1071	0.0018	1.0000							
share_flag	0.0596	0.0478	-0.0452	-0.0004	-0.0062	-0.0028	0.0053	0.0427	0.0386	0.0074	1.0000						
cashflow /assets	-0.0025	-0.0018	0.0183	0.0235	0.4279	-0.1257	-0.1347	0.0155	-0.0046	0.0054	-0.0432	1.0000					
cashflow /assets_lag	0.0079	0.0111	0.0622	0.1058	0.6705	0.1404	0.1470	0.0112	-0.0010	0.1666	-0.0012	0.2592	1.0000				
loans	-0.0036	-0.0023	0.0046	0.2673	0.0185	0.1835	0.1942	0.0167	-0.0004	-0.0022	0.0466	0.0053	0.0032	1.0000			
grants_ scaled	0.0087	0.0070	0.0194	-0.0077	-0.0016	-0.0091	-0.0089	-0.0204	-0.0005	0.0110	0.0109	0.0243	0.0996	-0.0018	1.0000		
grants bal_share	0.1034	0.0944	-0.0680	-0.0054	-0.0099	-0.0310	-0.0160	0.0149	-0.0031	-0.0195	0.0440	0.0094	0.0164	0.0072	0.0120	1.0000	
grants_pl	0.0196	0.0107	-0.0345	-0.0032	-0.0026	-0.0103	-0.0055	0.0868	-0.0013	-0.0025	0.0224	0.0242	0.0979	0.0103	0.6645	0.1287	1.0000

Table 9. Descriptive statistics of variables used in the probit panel analysis on the sample of firms conducting R&D activity

Variable	Obs	Mean	Std. Dev.	Min	Max
subj_id	10936	1306571	599157.8	2874	8550606
year	10936	2008.351	3.047596	2003	2013
rdexpen	10741	0.0487381	0.2710512	0	23.91163
rdexpen_lag	9721	0.0461137	0.2785426	0	23.91163
rdexpen_lag2	9721	0.0797045	5.799881	0	571.7661
AM	10936	0.1516094	0.3586582	0	1
AS	10936	0.1087235	0.3113062	0	1
cash flow/assets	5906	0.0765903	2.863611	-218.4904	8.868546
cash flow/assets_lag	5127	0.1179085	0.325621	-6.140707	8.868546
cash holdings	10857	0.1118595	0.1524919	0	1
debt	10857	0.1750528	1.21359	0	118.8285
leverage	10861	0.5271086	1.87253	0	166.0836
d6	10860	0.3895311	1.364073	-0.121586	130.5734
d6_2	10860	0.2389175	1.233692	-0.3439121	118.8971
size_income	10779	16.81259	1.989624	3.851636	23.69622
growth	9734	10.21503	558.1165	0	50116.26
risk_oper	8021	0.6679421	8.782774	0	361.3599
share_issue_flag	10936	0.1067118	0.3087606	0	1
loans	10125	875780	4.73e+07	-3.13e+08	4.57e+09
grants_profit&loss	10866	333944.2	6310198	0	4.02e+08
grants_scaled	10863	0.0083297	0.0761769	0	3.324025
grants_balance_share	10864	0.0211222	0.0645531	0	1.233593

Table 10. Descriptive statistics of variables used in the probit panel analysis on the sample of firms conducting R&D activity managed by academics

Variable	Obs	Mean	Std. Dev.	Min	Max
subj_id	1658	1355084	545590.4	2874	3097492
year	1658	2008.277	3.047	2003	2013
rdexpen	1624	0.0410472	0.1269029	0	1
rdexpen_lag	1478	0.0363937	0.1188857	0	1
rdexpen_lag2	1478	0.0154488	0.0862437	0	1
AS	1658	0.1743064	0.3794872	0	1
cash flow/assets	904	-0.124693	7.275301	-218.4904	3.161315
cash flow/assets_lag	789	0.1168954	0.2654723	-2.292113	3.161315
cash holdings	1637	0.1055466	0.1554005	0	1
debt	1637	0.1658045	0.203043	0	2.084604
leverage	1638	0.502155	0.3781426	0.0020817	5.422615
d6	1638	0.3848567	0.3299903	0	5.254961
d6_2	1638	0.2327682	0.2861034	-0.0025259	5.1049
size_income	1631	16.7802	2.024642	7.313221	23.42287
growth	1480	1.634595	8.44349	0	228.4916
risk_oper	1238	0.4765082	3.183534	0	99.31533
share_issue_flag	1658	0.1115802	0.3149443	0	1
loans	1533	450105.8	9511401	-1.06e+08	3.09e+08
grants_profit&loss	1639	281808.5	1647646	0	3.49e+07
grants_scaled	1639	0.0054082	0.031904	0	0.7657154
grants_balance_share	1638	0.0251265	0.071445	0	0.7425399

Table 11. Descriptive statistics of variables used in the probit panel analysis on the sample of firms supervised by academics

Variable	Obs	Mean	Std. Dev.	Min	Max
subj_id	17387	1357556	563042.7	2874	3098342
year	17387	2008.357	3.012186	2003	2013
rdexpen	16233	0.0032514	0.034581	0	0.9993462
rdexpen_lag	14780	0.0031529	0.0336554	0	0.9874085
rdexpen_lag2	14780	0.0011425	0.0208654	0	0.9749755
cash flow/assets	11151	0.0973706	2.453221	-57.11514	237.2789
cash flow/assets_lag	9642	0.1106428	2.551709	-38.67126	237.2789
cash holdings	17291	0.1560289	0.2079555	0	1
debt	17291	0.2381368	3.517956	0	440.0673
leverage	17301	0.793838	8.19308	0	533.9509
d6	17294	0.4901541	3.928641	-0.0366153	476.6107
d6_2	17294	0.3206996	3.623408	-0.0668816	440.0673
size_income	16669	15.66541	2.169227	2.079442	23.43664
growth	15167	6.668306	317.3847	0	25356.87
risk_oper	14332	21.18791	2314.111	0	276897.7
share_issue_flag	17387	0.0911025	0.2877632	0	1
loans	16200	550485.3	3.66e+07	-2.52e+08	4.57e+09
grants_profit&loss	17311	114974.1	1428499	0	1.41e+08
grants_scaled	17294	0.0126129	0.1771919	0	16.23723
grants_balance_share	17296	0.0147255	0.0613853	0	1.38248