Effectiveness of Business R&D in Emerging Economies; the Review of Research Evidence

Marek Martin[*]

Division of Economics, Faculty of Organization and Management, Lodz University of Technology, Poland

[*]**Corresponding author:** Dr. Marek Martin, Division of Economics, Faculty of Organization and Management, Lodz University of Technology, Poland, Tel: +374 10 23-72-61; E-mail: martin@p.lodz.pl

Abstract

This paper is aiming to summarize the research effort executed in the field of effectiveness of business research and development activities in the case of emerging economies. The initial quantitative research was carried out on the basis of econometric estimations of Cobb-Douglas production function. Two dependent variables were examined and both lagged and non-lagged effectiveness of various types of innovative business expenditures of manufacturing enterprises located in Poland. The survey is based on relatively large data basis obtained from public statistics (The Central Statistical Office). This paper was prepared by invitation from the editorial committee of Business and Economics Journal and summarizes the to date effort in the field of effectiveness of business R&D and innovation effort in the case of Poland as the example of an emerging economy. In general the review of the research work indicates the positive impact of business R&D (both internal and external) on relative sales and relative EBIDT (as profit proxy) growth. The positive impact of business R&D on relative EBIDT growth seems to be more consistent in terms of statistical significance.

Introduction

The problems of management and optimization of business innovative effort seem to be vital challenges in the contemporary economics especially in the period of global economic slowdown. Transferring a company's innovation expenditure into sales growth, profit and new product development is by no means straightforward at the microeconomic level. The results of business innovation and R&D are often unclear, indirect, and difficult to measure. This problem seems to be even more important in the case of emerging and transition economies, since research evidence and conclusions based on research work done in developed economies might not be easily transferable due to deferent stages of development of the two types of economies. According to World Economic Forum GCR [1] Poland is still in the transition between effectiveness and innovation driven stage witch at least in the theory should hinder and limit the general effectiveness of business research and development effort. The explanation of this is a rather complex issue, since one can argue that there are other investment opportunities for business units that are in essence less risky and at least as productive (due to potentially high returns) as opportunities offered in the field of risky and relatively unpredictable field of business R&D. Which in turn may result in higher investment in effectiveness oriented options, rather than accepting the higher risk in the field of innovation and R&D.

This study is aiming to identify on the basis of the available data derived from national statistics, the overall effectiveness of business research and development and various aspects of innovation effort. The analysis and considerations presented in this article are based on estimation of transformations of Cobb-Douglas production function of data representing companies located (1) in the Lodz Region (regional data) and (2) whole country (countrywide data).

The level of business R&D expenditure in Poland is consistently low by international standards. The level of spending is typical, or in some cases perhaps even lower, as for countries that are at the effectiveness based stage of economic development. This raises a question for reasons and factors that determine that situation. Is it because companies for some peculiar reason deliberately abandon that potentially rewarding opportunity to expand, depending on other, more "traditional" sources of growth, or is it because some other factors that actually limit R&D effectiveness and discourage firms from R&D effort play its role.

The more in depth investigation of the complexity and true factors determining the effectiveness of business innovative effort with the special emphasis on business R&D effort is vital for the overall development of the competitiveness of business units and via optimization of innovation and R&D effort might encourage companies to on one hand, spend more on innovation and on the other, gain healthier returns for both private and social benefits.

This paper was prepared by invitation from the editorial committee of Business and Economics Journal and summarizes the to date effort in the field of effectiveness of business R&D and innovation effort in the case of Poland as the example of emerging economy. This article summarises the highlights and main conclusions resulting from the research work related to the issue of effectiveness of innovation and business R&D in the emerging and transition economies based on the case of Poland.

The Methodology and Data

The review of the research work presented in the paper is based on the series of articles published between the year 2010 and 2014. In the

research on the issue of effectiveness of business innovation and R&D in the case of emerging economies scientific pursuits were based on the estimation of regression function which is the transformation of the Cobb-Douglas production function. The data utilized in the estimations of the regression functions was obtained from the public statistics and represent business innovation and R&D expenditure of individual companies followed by the basic output measures (relative sales growth and EBIDT relative growth) of medium and large manufacturing companies (50+) located in Poland. Companies that employ less than 50 employees are excluded from the research sample because they are not covered by yearly survey of innovative activities carried out by Central Statistical Office.

The initial version of the regression function utilised in the research is specified underneath.

$$\frac{Y^*_{t} - Y^*_{t-1}}{Y^*_{t-1}} = \beta 0 + \beta 1 \frac{EMP_t - EMP_{t-1}}{EMP_{t-1}} + \beta 2 \frac{R\&DInt_t}{y_t} + \beta 3 \frac{R\&DExt_t}{y_t}$$

$$+ \beta 4 \frac{NIE_t}{y_t} + \beta 5 \frac{IETech_t}{y_t} + \beta 6 \frac{IESoft_t}{y_t} + \beta 7 \frac{IEBuild_t}{y_t} + \beta 8 \frac{IEMDom_t}{y_t}$$

$$+ \beta 9 \frac{IEMImp_t}{y_t} + \beta 10 \frac{IETrai_t}{y_t} + \beta 11 \frac{IEMark_t}{y_t} + \beta 12 \frac{IERem_t}{y_t}$$

Description of variables

Y- sales or EBITD (earnings before interest tax and depreciation) depending on the type of the research

EMP – total employment

R&DInt – internal research and development expenditure

R&DExt – external research and development expenditure

NIE – non-innovation capital expenditure

IETech – innovation expenditure on new technologies

IESoft – innovation expenditure on software

IEBuild – innovation expenditure on buildings (associated with innovative activities or investment)

IEM Dom – innovation expenditure on domestically made machinery

IEM Imp – innovation expenditure on imported machinery

IETrai – innovation expenditure on training (associated with innovative activities or investment)

IEMark – innovation expenditure on marketing

IERem – remaining innovation expenditure

On the basis and limitations and availability of data, the business R&D in the research is divided into two general categories:

• Internal business research and development - activities carried out by a particular business unit regardless of the sources of funds utilized to finance them. Internal R&D expenditure includes both running costs and capital expenditure,

• External business research and development - includes R&D activities performed outside of the particular business unit by both domestic and foreign contractors.

The quantitative research is based on the estimation of the regression function that is based on the transformation of Cobb-

Douglas production function. The final version of the linear mathematical regression model was created on the basis of logarithm of both sites of classical Cobb-Douglas equation. The base model is based on relative increases (i.e. expenditures), instead of levels of capital. This approach is expected to better capture and reflect small changes of independent variables and is easier to implement.

The model, despite the fact that it is easy to implement and estimate, allows for decomposition and examination of the impact of various categories of independent variables (innovation expenditure). The selection of dependent variables utilised in the cited research allows for examination of unique and potentially practical relationships. In this review two dependent variables were taken under consideration in various forms of models. The first dependent variable was defined as the relative growth of sales, that represents the direct transformation of the Cobb-Douglas production function. The second dependent variable was defined as the relative growth of earnings before interest, tax and depreciation (EBITD), that is considered as the most suitable measure of profitability of innovative activities at the firm level, since it takes under consideration only short term costs and revenues that reflect the core of business operations at the firm level. Via selection of second dependent variable the long term factors like i.e. depreciation and financial costs were omitted in order to grasp the short term changes of output measures reflecting the real business operations.

The discussed research regarding the issue of effectiveness of business R&D and innovation effort in the case of emerging economies presented in a series of articles focused initially on the regional analysis of companies located in Central Poland (the Lodz Region) – the regional research [2-4]. The later part of the research [5-8] was undertaken on the basis of nationwide data reflecting all regions in Poland - the countrywide research.

The Research and Key Findings

The regional research

The first in the series of papers [2] is devoted to more general aspects of the issue of effectiveness of business R&D and innovation activities in the case of emerging economies. The empirical research was based on regional data and econometric estimations of the regression functions. The main conclusions resulting from the research in general confirm statistical significance of external R&D effort, this finding was confirmed on the basis of various subsamples. The research evidence in that respect seems to be rather firm and convincing. The research seems to initially justify the conclusion that external R&D effort is the optimal form of engagement into business R&D process for companies in question. It is worth to underline, this finding was the case despite the fact that Poland, according to WEF Global Competitiveness Report, is a country that is in transition between efficiency and innovation driven stage of development [1].

On contrary, all except one subsample the firms and estimations didn't allow to identify statistical significance of internal business R&D expenditure. Only for the subsample of especially, in terms of regularity, innovative firms, firms that in each year of the seven year time series reported R&D expenditure and after a series of extensive investigation certain negative significance of internal R&D was identified. This finding is particularly important when one takes under consideration significant differences in terms of levels of internal and external R&D expenditure in the research sample. Negative impact of

internal business R&D expenditure was identified despite the fact that on average internal research and development expenditure is 5,5 times higher than external research and development expenditure. Which might suggest serious misallocation problems in the field of the business internal R&D activities due to the lack of expertise or other negative synergic effects, i.e. weak and ineffective cooperation with environment and problems with commercialization of the results of internal R&D effort.

This overall important conclusion regarding positive impact of external business R&D seems to be rather convincing and backed by strong statistical significance of external R&D expenditure. On can add that this finding seems to be also quite interesting for a couple of reasons:

• The statistical significance of external R&D expenditure is in fact noticeably more consistent than the statistical significance of any other "traditional" kind of innovative expenditure i.e. machines (domestic or imported), buildings, etc.,

• Consistent significance of external R&D expenditure was proved despite the fact that the level of external R&D spending was noticeably lower than the level of expenditure reflecting other independent variables,

• The rather consistent positive significance of external R&D expenditure contrasts quite strongly with insignificance, in most cases, of internal R&D expenditure. This issue seems to be particularly interesting and should to be a subject of further scientific undertakings.

The research suggest substantial room for improvement for the level of business R&D spending (business R&D intensity) from the point of view of selected for the model dependent variable (relative sales growth).

The next paper [3] in the series of articles is devoted to the issue of relations between export and domestic sales on one hand and business R&D and innovation effort on the other. This research is also based in regional data (Lodz Region) and relative sales growth as the dependent variable in the econometric model. As far as the issue of the impact of business innovation and R&D on domestic and export sales is concerned, the research allows to draw three general conclusions:

• One can observe the existence of overall significant relationship between innovation expenditure and the volume of both domestic and export sales in the case of firms active in the field of R&D. Although strong influence of innovation expenditure on both domestic and export sales is generally unquestionable, on the basis of this and other research undertakings, the study revealed a significant differences in term of the factors determining the volume of export and domestic sales.

• There are strong differences between factors determining domestic and export sales. The research proved that domestic sales is mainly driven by external R&D expenditure, innovative expenditure on software, innovative expenditure on buildings (linked to innovation). Export sales is driven by acquisitions of machines (both domestically manufactured and imported).

• The study revealed significant differences between factors driving both export and domestic sales identified in the presented research and the results of other research work carried out in more developed countries [9]. The most noticeable difference in that respect is the lack of statistically significant impact of business R&D on export sales for firms in the research sample. It is rather hard to identify the reasons for the lack of significant impact of R&D expenditure on the export sales relative growth. The possible interpretation of this finding might be:

(1) The stage of development of the economy – other studies carried out in i.e. Spain, Germany, France, UK, Austria suggest strong positive relationship between company R&D expenditure and export sales,

(2) Rather weak overall export potential of the local economy (Lodz Region),

(3) Relatively low overall level of business R&D expenditure of local firms.

(4) Rather weak overall effectiveness of business research and development effort associated with the stage of the development of economy.

One can also notice certain differences in terms of the impact of innovative expenditure on machines on the performance of export sales between the results of this research and the results of other scientific undertakings. The presented research revealed a significant positive relationship between innovative expenditure on machines on export sales relative growth. This finding remains in contrast with the results of the work done by Pianta and Vaona [9] who found out on the basis of samples of European and Italian firms, strong negative relationship in that respect.

The third research in the series of articles is also based on regional data and is related to the problem of maximizing the return on business innovation expenditure [4]. The main idea was to look at different elements and forms of innovation expenditure/effort and asses their impact over relative sales growth from the point of view of maximization of results of business innovative effort. In the light of the research evidence the overall effectiveness of business innovation expenditure from the point of view of its components seems to rather limited. Many components of business innovation expenditure seem not to be easily, or at all, transferable into total relative sales growth and its components, that is domestic sales relative growth and export sales relative growth. As far as total sales relative growth is concerned, among 13 potential factors driving sales growth, that have been taken under consideration in the initial version of the model only few of them proved to be statistically significant as factors that influence relative sales growth of business units taken under consideration in this survey. Among components of innovation expenditure included in the initial version of the model only external R&D expenditure relative to sales lagged one year and innovative expenditure on domestically manufactured machines relative to sales lagged one year showed statistically significant impact on sales relative growth. No other innovative expenditure was found statistically significant on the basis of total sales relative growth model. Therefore in order to increase total sales relative growth and boost overall effectiveness of innovation expenditure it seems to be advisable in the light of the evidence, to focus company innovative expenditure in the first place on investment in external research and development and on investment in machines, especially manufactured domestically. What seems to be of significant importance is the variation in the value of estimated coefficients in that instance. The values of estimated coefficients defer by an order of magnitude. In the case of coefficient for external R&D in respect to relative sales growth and innovative expenditure on domestically manufactured machines estimated values of coefficients are: 6,35 and 0,57 respectively (both coefficients are highly statistically significant). This finding might suggest certain

degree of underinvestment in business research and development activities in the case of companies in the research sample and therefore room for profitable improvement in the field of business R&D expenditure, especially executed externally.

As far as the factors driving the components of total sales relative growth, that is: (1) domestic and (2) export sales relative growth, are concerned, the picture seems to be more complicated. On the basis of the results of econometric estimations the statistically significant factors driving domestic sales relative growth, on top of employment relative growth, include: external R&D expenditure lagged one year (the value of estimated coefficient equals 6,7), innovative expenditure on software lagged one year (the value of estimated coefficient equals 28,3) and innovative expenditure on buildings (new buildings associated with innovative activities), (the value of estimated coefficient equals 2,8). Extremely high value of coefficient for innovative expenditure on software might suggest significant underinvestment in the field of IT and therefore significant room for improvement in this area. In the case of factors driving export sales relative growth only two elements, on top of employment relative growth, are statistically significant on the basis of the research evidence. The regression analysis proved the highest value of estimated coefficient (equals 1,2) in the case of relative to sales innovative expenditure on imported machines lagged one year. The value the coefficient in the case of relative to sales expenditure on domestically manufactured machines lagged one year in noticeably smaller (equals 0,6). The fact that imported machinery are more competitive and better suited for foreign markets and therefore more efficiently supports export sales in comparison to the impact of domestically manufactured machines is in if fact in line with the so called "scientific guess" in that instance and therefore somehow confirms the validity of the findings. The lack of statistical significance of business research and development expenditure (internal and external) might suggest low or in fact statistically insignificant effectiveness of business R&D effort from the point of view of foreign markets. The more comprehensive deliberation upon this finding exceeded the limitations of the paper and should to the subject of future scientific pursuits. The possible explanations of this finding might be concerned with for instance the lack of critical mass (due to low overall level of business R&D expenditure of companies in the research sample) and the possible problems associated with the lack of knowhow and expertise in the field of business R&D.

I general in the light of the data and analysis business R&D effort does not seem to be the most effective route to maximize export sales for companies operating in this particular emerging economy and at its stage of economic development (according to World Economic Forum economy of Poland is in transition between effectiveness and innovation driven stage, what might explain a rather mixed picture of business R&D effectiveness of firms in the research sample). Investment in more "traditional" assets in comparison with knowledge and R&D seems to be more efficient at least at the current stage of economic development. A number of export oriented companies in Poland are in fact suppliers of intermediate products (sometimes as subsidiaries) for foreign manufactures of end user products. Therefore modernization effort via acquisition of optimized, sometimes matured and appropriate, from the foreign customers point of view, technologies and machines (both imported and domestically manufactured) might be more appropriate and economically effective way to follow instead of, at least at the time being, engaging in the risky, capital intensive and in many cases unpredictable business research and development undertakings. In the light of presented research evidence business R&D expertise and knowhow seems to be more appropriate and competitive for domestic market needs.

The countrywide research

The country wide research on the issue of effectiveness of business R&D is based on econometric estimations of two types of dependent variables: (1) relative sales growth and (2) relative EBIDT growth as the proxy of profit growth. The main reason to add second dependent variable was to look at the research problem in a more comprehensive manner. The profit proxy target function potentially should allow for more complex and convincing conclusions since profit generation on the basis of classical economic theory is a very, if not the most important, aim of the business and economic activities.

The first research regarding country wide data regarding the issue of effectiveness of business innovative activities in the case of emerging economies was based on exploitation of relative sales growth model [5]. The results of the survey suggest significant and especially strong variation of the values of selected estimated coefficients in respect to the time lag applied in the model, especially in regard to innovation expenditure on software and innovation expenditure on new technologies. Since it is widely recognized in the literature that the results of various innovative expenditures, especially these related to R&D might give significantly delayed results, the above mentioned findings might also suggest significant need for extension of lag applied from the maximum three year lag applied in the presented study to probably around six year lag. The extension of lag applied in the process of model estimation should give an opportunity to find out if any longer period trend does exists in respect to the effectiveness of specified in the model innovative expenditures.

The study reviled the noticeable differences between the relative sales growth of firms in the total sample of firms (including all firms covered by the survey, both active and not active in the field of business R&D) and firms in the subsample of firms active in the field of business R&D. The firms active in the field of business R&D grow in (terms of relative sales growth) on average faster (the average relative sales growth equals 0,11), than firms in the total sample, where the average relative sales growth equals 0,08. This suggest that firms active in field of business R&D grow faster than average.

The study revealed strong variation of the impact of various innovative expenditures on relative sales growth. In the case of the estimations based on total sample of firms the strongest influence over relative sales growth is observed in the case of innovation expenditure on software, new technologies and remaining innovation expenditures. In the case of innovation expenditure on new machines both domestically manufactured and imported the moderate level of impact over relative sales growth was identified. In the case of external business research and development the relatively weak level of influence was identified.

The results of estimations based on subsample of firms active in the field of R&D also indicate strong variation of the impact of various innovative expenditure over the relative sales growth. The strongest impact was identified in case non-innovative capital expenditures. The moderate impact was identified in the case of: innovation expenditures on machines (both domestically manufactured and imported), buildings associated with innovative activities and internal business R&D. In the case of business research and development expenditure in the subsample of firms active in the field of business R&D, the

noticeable higher level of influence over relative sales growth was identified in comparison with the total sample of firms.

One can identify significant, delayed positive effects of certain innovation expenditures over relative sales growth. In the case of estimations based on total sample of firms, the significant delayed positive effects of innovation expenditures take place in the first place in the case of innovation expenditures on software and innovation expenditure on new technologies. In the case of innovation expenditure on software the strong positive statistically significant impact of this expenditure on relative sales growth takes place two years after expenditure (the value of estimated coefficient equals 5,48). One year after the expenditure one can expect strong statistically significant negative impact of innovation expenditure on software on relative sales growth (the value of estimated coefficient equals -6,43). These findings are in line with the general understanding of the issue on investment in the IT and software solutions – that in the short run might cause certain problems associated with i.e. the learning curve concept. Positive economic results in this respect come with time as employees acquire and master new knowledge. In the case of innovation expenditure on new technologies the lag between the expenditure and occurrence of positive economic effects is even longer. In the case of innovation expenditure on new technologies the strong positive statistically significant impact of this expenditure on relative sales growth takes place three years after the actual expenditure (the value of estimated coefficient equals 5,76). One year and two years after the expenditure one can expect strong statistically significant negative impact of innovation expenditure on new technologies on relative sales growth (the value of estimated coefficient equals -4,67 and -5,43 respectively). In the case of innovative expenditure on new technologies the lagged positive effect might be also explained on the basis of learning curve concept. The existence of longer lag might suggest that it takes longer to master new knowledge relevant to new technologies than new IT and software solutions that are perhaps more standardized and easier to utilize in the efficient way. The innovation expenditure on imported machinery on average has the strongest positive effects one year from the actual expenditure.

The estimations based of the subsample of firms active in the field of R&D indicate the delayed positive effects of internal business expenditures on R&D. The positive effect of internal business R&D takes place on year after the expense was made (the value of estimated coefficient equals 1,33). In the year when the expense was made one can observe negative effect (the value of estimated coefficient equals -1,06).

On top of the above mentioned findings, an interesting regularity subject to the lag applied, of the effectiveness of non-innovation capital expenditure was observed in the case of both samples. This regularity refers to the (1) positive moderate effect of non-innovation capital expenditure over the relative sales growth in the year when the expense was made, (2) the strong negative effect lagged one year, (3) relatively strong positive effect lagged two years and (4) close to zero effect lagged three years. The quite similar regularity applies to the innovation expenditure on buildings. The more in depth investigation of the nature of above specified regularities exceeds the limitation of this paper, but the issue itself constitute an interesting subject of future investigation.

The second paper based on countrywide data [6] is the continuation and extension of the previous research work. The main reason was to search for more lagged effects of business innovation and R&D expenditure over relative sales growth as the dependent variable, the

maximum lag was extended to six years in comparison to three years lag applied in the research above.

The study was based on a series of tests of the relative sales growth econometric models using (1) total sample of firms covered by the survey and (2) subsample of firms active in the field of business R&D. The final analysis was based on four models. Model 1 was based on the total sample of firms – regression lagged 0 to 5 years. Model 2 was based on the subsample of firms active in the field of business R&D – regression lagged 0 - 5 years. Model 3 was based on the total sample of firms – regression lagged 0 to 6 years. Model 4 was based on the subsample of firms active in the field of business R&D – regression lagged 0 - 6 years.

The estimations based on the total sample of firms with maximum 5 year lag applied (Model 1) indicate the statistical significance of: non innovation capital expenditure, innovation expenditure on software, innovation expenditure on domestically manufactured machines, non-innovation capital expenditure lagged one year, innovation expenditure on domestically manufactured machines lagged one year, non-innovation capital expenditure lagged two years, innovation expenditure on new technologies lagged three years, innovation expenditure on domestically manufactured machines lagged three years, innovation expenditure on imported machines lagged three years, innovation expenditure on training lagged three years, innovation expenditure on buildings lagged five years, innovation expenditure on imported machines lagged five years. The strongest positive interaction between innovation expenditure and the dependent variable (relative sales growth) was observed in the case of innovative expenditure on training lagged three years. This finding might suggest the strong and moderately delayed (three year lag) impact of innovation expenditure on training. One can also observe the negative non-lagged (0 years lag) impact of statistically significant categories of innovation expenditure, positive interactions between various categories of innovation expenditure and the dependent variable were observed when longer lag was applied.

The model estimations based on the sample of firms active in the field of R&D with maximum 5 year lag applied (Model 2) indicate the statistical significance of: non innovation capital expenditure, innovation expenditure on domestically manufactured machines, external business R&D expenditure lagged one year, non-innovation capital expenditure lagged one year, innovation expenditure on domestically manufactured machines lagged three years, innovation expenditure on imported machines lagged three years, innovation expenditure on training lagged three years, innovation expenditure on buildings lagged four years, innovation expenditure on buildings lagged five years. Again the strongest statistically significant three year lagged, positive impact of innovative expenditure on training was observed. The moderate statistically significant one year lagged negative impact of external R&D expenditure was observed, what may suggest the more lagged positive returns on business B&D and negative, in respect to the relative sales growth, short term effects of external business R&D expenditure. The similar regularity (short term - 0 lag- negative effect and longer term – three year lagged - positive effects) was observed in case of innovation expenditure on domestically manufactured machines.

On the basis of estimations based the total sample of firms active in the field of R&D with maximum 6 year lag applied (Model 3) one can observe a statistically significant 6 year lagged positive effects of external business R&D expenditure. This finding to certain extent corresponds with the statistically significant negative effect of one year

lagged external R&D expenditure presented in the Model 2 and might suggest more lagged (6 or more years) effects of business R&D expenditure. Model 2 suggests that one can expect negative effects between business R&D and relative sales growth when the relatively short (i.e. one year) lag is examined. Estimation of non-lagged independent variables (non-innovation capital expenditure and innovation expenditure on domestically made machinery) indicates negative impact over relative sales growth. The gradual positive impact of various innovation expenditures appear in line with the increased lag applied. The maximum positive effect was identified in the case of innovative expenditure on training lagged three years.

The estimations based on the subsample of firms active in the field of R&D with maximum 6 year lag applied (Model 4) proved that the following innovation expenditures seem to be significant: non innovation capital expenditure and innovation expenditure on domestically manufactured machines, external business R&D expenditure lagged one year, non-innovation expenditure lagged one year, innovation expenditure on domestically manufactured machines lagged three years, innovation expenditure on imported machines lagged three years, innovation expenditure on training lagged three years, and innovation expenditure on buildings lagged five years. The interesting regularity that can be observed on the basis of this model refers to the gradual build-up of positive results of various innovation expenditures in line with the increased lag between the actual expenditure and the observed lagged effect.

In comparison to previous research and econometrical estimations based on the shorter maximum lag applied [5], it seems that the above specified models, that apply maximum 6 and 5 years lag, are capable only to capture the relatively strongest interactions among the various types of independent variables and relative sales growth. It seems that in practice the regression analysis based on relatively longer maximum lag of independent variables, loose the sensitivity over the more subtle relations and indicate only the main interactions. The findings regarding the main interactions are in general in line with the previous estimations based on shorter (0 to 3 years) maximum lag applied. One can assume that in the presented paper the "trade of" between the number of observations and the longer lag applied is in favour of the number of observations, since the longer lags applied significantly diminish the number of available observations for estimation. The potential solution to this problem seems to be to fold: (1) the extension of the longer time series of data and (2) the alteration of the econometrical model and methodology. Both directions are subject of further consideration. In respect to the selected categories of innovative expenditures, the lagged positive effects were identified in comparison with observed negative non lagged effect. The non-lagged effects are in most cases negative (except of relative employment growth), the positive impact starts to occur for lagged interactions.

The next paper related to countrywide data [7] is based on modified econometric model. The dependent variable was changed, relative sales growth was replaced with profit proxy - relative EBIDT growth. The main reason that the dependent variable was modified was to allow for more comprehensive analyses of the problem of effectiveness of business R&D and innovation effort, that reflect profit maximization theory of the firm.

The study revealed strong variation of the impact of various innovative expenditures on relative sales growth. In the light of the presented estimations part of independent variables incorporated in the model proved to be of no significant impact over the relative EBITD growth regardless the regularity of the R&D effort of the firms

in question and lag applied. The study showed that regardless of the R&D regularity, the following independent variables have no statistically significant impact: innovation expenditure on software, innovation expenditure on buildings, non-innovation capital expenditure, remaining innovation expenditure. The strongest statistically significant influence over relative EBIDT growth regardless of the R&D regularity was observed in the case: of innovation expenditure on training and marketing. The study revealed, highly statistically significant and consistent regardless of the R&D regularity, positive impact of business R&D lagged five years over relative EBITD growth. This consistency was especially observed in the case of internal business R&D. The above finding is in line with the results of the work done by Wanga, Ch-H, Lua, Y-H, Huang, Ch-W and Lee, J-Y [10] in respect to the consistently positive effects of business R&D effort over firms' performance. As the business R&D regularity increases the coefficients estimated for internal business R&D tend to show slightly greater values. The same tendency was observed in the case of external business R&D on the basis of estimations of sample A, B and C (subsamples of total sample subject to growing regularity of business R&D effort). The noticeably greater effect of external business R&D, than internal was found on the basis of model/subsample A, B and C (subsamples A, B and C include firms that at least twice, four times and six times respectively in the ten year time series reported R&D expenditure). This finding is consistent with the results of research work done by Mataa and Woerther [11] on the basis of a sample of Swiss firms. In the case of the sample of firms showing the very strong regularity of business R&D no statistically significant impact of external business R&D was observed, this may initially suggest that firms showing the highest R&D regularity relay mainly on internal business R&D. It might be also the case, that for some hard to understand at this stage of the research reasons, that external R&D effort becomes ineffective, in respect to EBIDT, in the case of firm showing the highest R&D regularity. The study reviled significant, delayed positive effects of certain innovation expenditures over relative EBITD growth. The effects of business R&D expenditure are consistently positive and are lagged five years. The positive effects of other than R&D innovation expenditures tend to appear as the lag increases, this was especially observed in the case of innovation expenditure on marketing on the basis of two samples of firms that at least two and four times in the time series reported R&D expenditure and sample of firms that at least six times in the time series reported R&D expenditure (negative three years lagged effect and positive four years lagged effect was observed). In the case of samples of firms that at least eight and ten times in the time series reported R&D expenditure only three years lagged negative effect was observed in that respect. This might suggest that in the case of highly dedicated in terms of business R&D regularity companies, the returns to investment on marketing are more questionable.

The comparison of the results of the current survey based on relative EBITD growth and the previous estimations, [4,5] based on relative sales growth as the dependent variable indicate that various categories of innovation expenditure at the business level have far greater impact on sales growth (exemplified by relative sales growth) than on profit growth (exemplified by relative EBITD growth). The difference in terms of impact over dependent variables between the two above mentioned approaches/variables is close to an order of magnitude or greater. This may suggest that the EBIDT relative growth is to smaller extent determined by business innovation expenditure, than relative sales growth. In this case other factors that are not specified in the model have a greater impact over profit proxy

dependent variable. One could assume and hypothesize that business innovation effort is targeted to smaller extent at profit growth than it is targeted at sales growth. The above observation may also suggest, that the firms in the research sample are on average in terms of their innovation effort more sales growth, than profit growth oriented. One could suggest that the traditional neoclassical profit maximization theory of the firm, in fact to the rather limited extent explains the economic and business aims and motives behind innovation effort of the firm in the research sample. The alternative, sales growth maximization oriented theories of the firm, might be more appropriate and applicable.

Another explanation might be, that in the case of highly innovative – R&D oriented companies, profits are being reinvested, what in turn limits the growth of profitability. In fact the research indicates that as the regularity of the business R&D increases the dependent variable average decreases. The previous research, [4] reviled the noticeable differences between the relative sales growth of firms in the total sample and firms in the subsample of firms active in the field of business R&D. Firms active in field of business R&D have noticeable higher values of relative sales growth. In the case of the current research the dependent variable average seems to decrease as the R&D regularity increases. This might initially suggest, that as the R&D regularity increases, firms show lower profit growth due to heavy R&D investment and/or in a sense might become less profit oriented.

The last of the papers taken under consideration in this review of main points from to date research is also based on countrywide data and modified target function (relative EBIDT growth as the dependent variable) incorporated in the model [8]. The main difference in comparison with the previous research is that the econometric estimations of the model are based on the more sophisticated methodology that allows for identification of variable and fixed effects on the basis of panel data analysis. The results of panel data estimations based both on classical least square and generalized least square method revealed strong variation of the impact of various categories of innovative expenditure taken under consideration in the initial version of the model and high significance associated with mostly positive impact of both internal and external business R&D effort over relative EBITD growth. The positive impact was found mainly in the case of random effects. The analysis of random effects of business R&D activates indicate significant, positive and strong to moderate impact of this category of innovative effort. Random effect data analysis revealed that the results of external R&D are less lagged (three years) and stronger, than the effects of internal business R&D (five years lag). These conclusions formulated on the basis of the narrowed subsample and generalized least square estimation method of panel data analysis are in that particular respect opposite to the results of estimations based on classical least square method presented earlier in the paper. It seems to be worthwhile to further investigate this issue and find out if there is in fact certain regularity in terns the timing of effects of internal and external business R&D, or such regularity in fact does not exist.

Conclusion

Research and development in most cases consists of a complex and interdependent set of activities. The significance of various aspects of innovation and R&D activities in the value creation is objectively complicated and hard to asses. The value creation potential of a given branch of industry is to certain extent indirectly based on the general science achievements and developments. According to Gibbons and Johnston [12] science is creating a certain stock of knowledge together with the tools and techniques that are taken advantage of and utilized by business units that undertake R&D efforts.

In general the to date research show in most cases positive impact of business R&D over both relative sales growth and relative EBIDT growth. In the case of estimations based on relative sales growth as the dependent variable research give a bit mixed picture. On the basis of regional (Lodz Region) research the effectiveness of external business R&D effort seems to be more statistically significant than internal R&D. The nationwide research and estimations based on the subsample of firms active in the field of R&D indicate the delayed positive effects of internal business expenditures on R&D. This deference in terms of effectiveness of internal and external business R&D might reflect certain characteristics of the region in comparison with country as a whole.

The research based on relative EBIDT growth as the dependent variable suggest significant effectiveness of both internal and external business R&D, the results are more consistent and balanced in that respect. Only in the case of firms showing the very high regularity of business R&D no statistically significant impact of external business R&D was observed. Author is planning to investigate further the issue and reasons for the lack of statistical significance of external business R&D in the case of firm showing very strong regularity of business R&D. One can conclude that business R&D, both internal and external, might be potentially effective in given macroeconomic conditions of an emerging economy provided that it is well managed and targeted.

As far as the issue of impact of business innovation expenditure and R&D over export and domestic sales is concerned, the regional research showed in the first place that domestic sales is mainly driven by external R&D expenditure, innovative expenditure on software, innovative expenditure on buildings (linked to innovation). Export sales is driven by acquisitions of machines (both domestically manufactured and imported).

As far as the limitations and scope for future research are concerned, it seems to be advisable to continue the research and estimations on the basis of more refined and advanced methods and models. It might be achieved for instance via: (1) the more comprehensive utilization of panel models combined with search for fixed and variable effects, (2) implementation of different dependent variables. Theory, in certain cases (i.e. biotechnology sector), suggests the more than 6 year lagged effects of business innovation activities. It seems to be advisable to also further extend the maximum lag applied in the estimations in order to fully examine the possible existence and pattern of more lagged effects of business innovation and R&D effort in certain categories of business units.

As far as the external validity of the research is concerned the key results may be of significant interest for other Central Eastern European countries and other economies in transition. The validity of the research for other emerging economies might be also justified to certain extent, since Poland, as the emerging economy, might be considered as average among other emerging economies, in terms of rate of growth and the overall level of development of economy. The size of the economy might be also in a sense considered as average in the wider context.

Acknowledgments

References

1. World Economic Forum (2009) The Global Competitiveness Report 2009-2010, WEF.

2. Martin M (2010) The Effectiveness of Business Research and Development in Emerging Economies, The Regional Analysis, Global Conference On Business and Finance Proceedings 2: 440-452.

3. Martin M (2011) The Impact of Business Innovation on Domestic and Export Sales In Emerging Economies: the Regional Analysis [in:], A. Chiu, M-L. Tseng, Proceedings of 2011 International Conference on Asia Pacific Business Innovation & Technology Management (APBITM).

4. Martin M (2012) Maximizing the Return on Business Innovation Expenditure in the Case of Emerging Economies; Regional Analysis, [in:], S. Baby, V.K. Banga (ed.) International Conference Proceedings of PSRC Penang Malaysia 2012, p 145-149,

5. Martin M (2013) The Effectiveness of Business Innovative Activities in the Case of Emerging Economies; The Exploitation of Relative Sales Growth Model, INTENSITY. Int J of Applied Social Science Res 2: 60-66.

6. Martin M (2013) The Effectiveness of Business Innovative Activities in the Case of Emerging Economies; in Search for the Lagged Effects. Int J of Bus, Manage & Social Sci 2: 77-81.

7. Martin M (2014) Effectiveness of Business Innovation in Emerging Economies; Exploitation of Relative Profit Growth Model. World Rev of Bus Res 4: 34-48.

8. Mataa J, Woerter M (2013) Risky innovation: The Impact of Internal and External R&D Strategies upon the Distribution of Returns. Research Policy 42: 495-501.

9. Martin M (2015) Effectiveness of Business Innovation and R&D in Emerging Economies; The Evidence from Panel Data Analysis. J of Econ Bus and Manage 3: 440-446.

10. Wanga CH, Lua YH, Huang CW, Lee JY (2013) R&D, Productivity, and Market Value: An Empirical Study from High-technology Firms. Omega 41: 143-155.

11. Pianta M, Vaona A (2007) Innovation and Productivity in European Industries. Economics of Innovation & New Technology 16: 485-499.

12. Gibbons M, Johnston R (1974) The Role of Science in Technological Innovation. Research Policy 3: 20-243.