Abstract - Economic crisis and stronger, due to economic slowdown, competition causes the growing concern for return on investment issues and adequate investment strategies. This paper is aiming to identify, on the basis of estimation of Cobb-Douglas production function, potentially effective priorities, among various types of innovation oriented investment options, that might in the light of research evidence help to maximize the return on innovation expenditure of manufacturing companies in the case of emerging economy. The study proves the strong variation in terms of the effectiveness of various types of innovative expenditure measured by their impact on relative sales growth. The strong variation between factors driving domestic and export sales relative growth and return on business innovation in that context has been also identified.

Keywords - business innovation, innovation management, research and development, effectiveness, returns on innovative expenditure, innovation effectiveness

I. INTRODUCTION

In the current economic status quo the potential and ability to create innovation is becoming a critical factor determining the long term economic wellbeing of business units and national economies. At the macroeconomic level the ability to transfer innovation into economic effects is to the large extend unquestionable, according to E.F. Denison [2], social wealth is determined by technical progress in up to 90% determined by the technical. These findings are consistent with more recent studies by R.M. Sollow [6] and P.M. Romer [8] who indicate the technical change as the major sources of productivity growth in the long term. According to L. Sveikauskas [7] the overall rate of return to R&D is quite impressive; it is estimated 25% as for private return and 65 % for overall social returns. Authors distinguish three stages of national economy development [5]: the first stage - factor driven economy, the second stage - efficiency driven economy, the third - innovation driven stage of development. According to the WEF [9] Poland is still in transition between the efficiency and innovation driven stage of economy. The level of the development of Polish economy might, at least in the theory, hinder the effectiveness of innovation and R&D undertakings of business units.

The effectiveness of business innovation at the microeconomic level is far more complex issue. One of more recent studies related to this issue focusing on product innovation strategies and performance of new high-tech firms in China proved that the innovation effectiveness is to large extent determined by environmental factors and institutional support [1]. Another study done in Finland underlines the fact that profiting from innovation requires strong complementary capabilities between R&D and other business activities within the firm, i.e.: marketing and manufacturing [4]. Other authors [3] stress the importance of so called “behind innovation”. In that respect effectiveness of commercialization strategy is vitally important. The cost of innovation must include creation of novelty, development and commercialization. The overall effect of innovation process depends on proper product positioning, well tailored pricing policy along product life cycle. Therefore identification of effective paths for maximizing return on business innovation seems to be relatively important issue. Investment in innovation is a coherent process aiming at optimizing the ratio and leverage between tangible and intangible innovation assets followed by maximizing the returns on both internal and external investment undertaken by business units. In the microeconomic context scholars stress the necessity to enhance innovation effectiveness in the following ways [3]:

- Through more consistent, organic, profitable sales growth. Which translates in practical terms into the new business creation or expansion challenge,
- Much faster pace of innovation,
- Significantly higher productivity from our innovation investment.

The considerations presented in the paper address, on the basis of econometrical tools and analysis, the issue and possible routes and priorities, that night lead to higher productivity of business innovation expenditure in the economic context.

II. THE MODEL DESCRIPTION AND DATA CHARACTERISTIC

The survey of innovation effectiveness at the business level presented in this paper is based on the estimation of regression function, which is the transformation of Cobb-Douglas
production function. The data utilized in the estimation of the regression function are obtained from the public statistics and represent various innovation and R&D expenditure associated with basic output measures (relative total sales growth, relative domestic and export sales growth) of medium and large (according to EU standards) manufacturing companies located in Central Poland (Lodz Region). 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 (GUS). The initial version of the regression function taken under consideration in this paper is specified underneath (1).

\[
\frac{y^*_t - y^*_{t-1}}{y^*_{t-4}} = \beta_0 + \beta_1 \frac{EMP - EMP_{t-1}}{EMP_{t-1}} + \beta_2 \frac{R \& DInt}{y_t} + \beta_3 \frac{R \& DExt}{y_t} + \beta_4 \frac{NIE}{y_t} + \beta_5 \frac{IETech}{y_t} + \beta_6 \frac{ICESoft}{y_t} + \beta_7 \frac{IEBuild}{y_t} + \beta_8 \frac{IEMDom}{y_t} + \beta_9 \frac{IEM Imp}{y_t} + \beta_{10} \frac{IETrai}{y_t} + \beta_{11} \frac{IEMark}{y_t} + \beta_{12} \frac{IERem}{y_t} + \beta_{13} \frac{R \& DInt}{TIE_t} + \beta_{14} \left( \frac{R \& DExt}{TIE_t} \right)^2 + \beta_{15} \frac{R \& DExt}{TIE_t} + \beta_{16} \left( \frac{R \& DExt}{TIE_t} \right)^2
\]

Data description:
EMP – total employment
R&DInt – internal research and development expenditure,
R&DExt – external research and development expenditure,
NIE – non innovative capital expenditure,
IETech – innovative expenditure on new technologies
ICESoft – innovative expenditure on software,
IEBuild – innovative expenditure on buildings (associated with innovative investment and activities),
IEMDom – innovative expenditure on domestically made machines,
IEMImp – innovative expenditure on imported machines,
IETrai – innovative expenditure on training (training associated with innovative activities or investment),
IEMark – innovative expenditure on marketing,
IERem – remaining innovative expenditure,
TIE – total innovative expenditure

The time series of the research sample cover the period between the year 1999 and 2006, which is in practice the longest time series data available for the individual companies, since the data gathered by public statistic is stored for around 7-8 years. The total sample of data comprises data of 257 companies covered by the questionnaire survey (PNT-02) carried out by Central Statistical Office in Poland between 1999 and 2006 year. PNT-02 survey is directed to medium and large (according to EU mythology employing 50 or more persons) manufacturing firms. The number of firms covered by PNT-02 survey in single consecutive years between 1999 and 2006 varied a bit more than 300 and a little bit less than 400 but 257 firms were covered by the survey in each year of the time series. This total sample of 257 firms is further referred to as “257 sample”. For the purpose of more detailed analysis a “75 sample” subsample of “257 sample” was identified. “75 subsample” represents companies that at least once in the 1999-2006 time series reported R&D (internal or external) expenditure regardless the size of expenses, 75 out of 257 meet that criteria. “75 subsample” proved to be useful for the estimations presented in the paper.

The initial model estimations were started on the basis of the „257 sample” and showed no statistical significance of both internal and external R&D expenditure followed by no significance of other innovative expenditures. Various estimations without and with one year delay of independent variables proved high statistical significance of employment relative growth and non innovative capital expenditure, which might support the idea that polish economy in general is still to large extent driven by efficiency, instead of innovation. The more detailed and comprehensive presentation of these results exceeds the limitations of this paper.

The first acceptable model that revealed statistical significance of business innovation and R&D expenditure was estimated on the basis of “75 sample” (samples of firms that at least in the time series reported R&D expenditure, table 1).

The final version of the model is specified underneath (2):

\[
\frac{y^*_t - y^*_{t-1}}{y^*_{t-4}} = \beta_0 + \beta_1 \frac{EMP - EMP_{t-1}}{EMP_{t-1}} + \beta_2 \frac{R \& DInt}{y_t} + \beta_3 \frac{R \& DExt}{y_t} + \beta_4 \frac{NIE}{y_t} + \beta_5 \frac{IETech}{y_t} + \beta_6 \frac{ICESoft}{y_t} + \beta_7 \frac{IEBuild}{y_t} + \beta_8 \frac{IEMDom}{y_t} + \beta_9 \frac{IEM Imp}{y_t} + \beta_{10} \frac{IETrai}{y_t} + \beta_{11} \frac{IEMark}{y_t} + \beta_{12} \frac{IERem}{y_t} + \beta_{13} \frac{R \& DInt}{TIE_t} + \beta_{14} \left( \frac{R \& DExt}{TIE_t} \right)^2 + \beta_{15} \frac{R \& DExt}{TIE_t} + \beta_{16} \left( \frac{R \& DExt}{TIE_t} \right)^2
\]

### Table 1

**CLASSICAL LEAST SQUARE METHOD MODEL:**
**ESTIMATION RESULTS BASED ON THE “75 SUBSAMPLE”**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Estimated coefficients</th>
<th>Standard error</th>
<th>T statistics</th>
<th>p level</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>0.0436024</td>
<td>0.013066</td>
<td>3.3369</td>
<td>0.00093</td>
</tr>
<tr>
<td>beta1</td>
<td>0.736434</td>
<td>0.07865</td>
<td>9.3634</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>beta3_1 (legged one year)</td>
<td>6.35582</td>
<td>1.74419</td>
<td>3.6440</td>
<td>0.00031</td>
</tr>
<tr>
<td>beta8_1 (lagged one year)</td>
<td>0.576071</td>
<td>0.296531</td>
<td>1.9427</td>
<td>0.05281</td>
</tr>
</tbody>
</table>

***, **, and * indicate significance at the 1, 5 and 10 percent levels respectively.

Determination coefficient $R^2 = 0.292214$
Adjusted $R^2 = 0.286491$
F (Fisher-Snedecor) statistic $(3,371) = 51.0567$ ($P < 0.00001$)

The model proves strong statistical significance of external R&D expenditure and certain significance of innovative experience on domestic machines delayed 1 year. No other innovative expenditure was found statistically significant on the basis of this model.

### III. Maximizing Export and Domestic Sales Via Innovation Expenditure

Another aspect of the study presented in the paper refers to the issue of maximization of domestic and export sales relative growth via innovation expenditure. After a series of
tests of the initial model, the final models of relative domestic and export sales growth were specified (3 and 4). All the remaining independent variables included in the initial version of econometric model (1) proved to be insignificant regardless of the lag applied or of the subsample used to carry out the estimations. Table 2 presents estimation results for the final model of relative domestic sales growth.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Estimated coefficients</th>
<th>Standard error</th>
<th>T statistics</th>
<th>p level</th>
</tr>
</thead>
<tbody>
<tr>
<td>const</td>
<td>-0.0199</td>
<td>0.012</td>
<td>-1.6608</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>beta1</td>
<td>0.4205</td>
<td>0.0718</td>
<td>5.8540</td>
<td>&lt;0.001  ***</td>
</tr>
<tr>
<td>beta3_1</td>
<td>6.7005</td>
<td>1.7623</td>
<td>3.8028</td>
<td>0.001   ***</td>
</tr>
<tr>
<td>beta6_1</td>
<td>28.3688</td>
<td>11.3593</td>
<td>2.4974</td>
<td>0.0136  **</td>
</tr>
<tr>
<td>beta7_2</td>
<td>2.7632</td>
<td>0.5542</td>
<td>4.9859</td>
<td>&lt;0.0001 ***</td>
</tr>
</tbody>
</table>

Note: ***, **, and * indicate significance levels of 1, 5 and 10 percent, respectively.

F (Fisher-Snedecor) statistic (4.295) = 39.2556 (p < 0.00001)

Determination coefficient $R^2 = 0.347378$

Adjusted $R^2 = 0.338529$

In the light of the research evidence the overall effectiveness of business innovation expenditure seems to quite limited. Many components of business innovation expenditure seems 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 (model 1) only 3 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 (2). 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 machines, especially manufactured domestically. What seems to be of significant importance is the variation in the value of estimated coefficients in that instance (see table 1). The values of estimated coefficients defer by an order of magnitude. In the case of coefficient for external R&D relative to sales lagged one year 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.

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Estimated coefficients</th>
<th>Standard error</th>
<th>T statistics</th>
<th>p level</th>
</tr>
</thead>
<tbody>
<tr>
<td>beta8_1 (lagged one year)</td>
<td>0.5722</td>
<td>0.2392</td>
<td>2.3920</td>
<td>0.0173  **</td>
</tr>
<tr>
<td>beta9_1 (lagged one year)</td>
<td>1.2082</td>
<td>0.3105</td>
<td>3.8900</td>
<td>0.0001  ***</td>
</tr>
</tbody>
</table>

Note: ***, **, and * indicate significance at 1, 5 and 10 percent, respectively.

Determination coefficient $R^2 = 0.148645$

Adjusted $R^2 = 0.140016$

F (Fisher-Snedecor) statistic (3.296) = 17.227 (P < 0.00001)
As far as the factors driving the components of total sales relative growth, that is domestic and export sales relative growth, are concerned, the picture seems to be more complicated. On the basis of the results of econometric estimations presented in the paper (see table 2) 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 presented research evidence. The regression analysis proved the highest value of estimated coefficient (equal 1.2 - see table 3) 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 is much smaller (equals 0.6 - see table 3). The fact that imported machinery is 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 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 insignificant level of 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.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES