

# “Factors of investments in automobile companies’ R&D”

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## Factors of investments in automobile companies' R&D

### Abstract

This paper studies what determines investment in R&D at major automobile companies of Japan and Germany as of from 2001 to 2015. For that purpose, accounting records and OECD and WWID databases were used. Based on regression models of panel data with random effects and fixed effects, some factors considerably influencing upon investment in R&D were found out. Such factors include: the total assets, amount of exports, market share, return on total assets, total revenue, profits and the income share of the wealthiest residents.

**Keywords:** factors of investment in R&D, automobile industry, Japan, Germany.

**JEL Classification:** G39.

### Introduction

This publication has been prepared within the framework of a research project supported by the RFH (Russian Foundation for Humanities) #15-32-01273. The main goal of the article is to find out specific factors of investment in R&D typical to the largest automobile companies of Japan and Germany.

At present, confirmation of influence of a great number of various factors upon investment in R&D can be found in the literature. In so doing, an active discussion was held and has been held up to the present among researchers concerning a role and importance of one or other factors.

Most commonly, in an empiric analysis the influence of factors is predetermined by branch-specific issues. One or other factors can dominate to a greater extent than others.

Branches have their specific features, in particular, market size, market structure, technological effectiveness, market segment, competitive activity level, nature of technologies and many others.

Thus, specific features inherent in one or another branch can to a greater extent determine a list of factors of investment in R&D.

Choice of the automobile branch is conditioned by the fact that automobile companies have a high share of R&D investment expenses (on the average, 7% of all expenses), product is easy to manufacture

and patent activity of companies' research divisions is rather high.

In addition, automobile companies refer to the market oligopolistic structure, which makes a high potential for competition between auto manufacturers.

In our opinion, reveal of factors is important for understanding the regularities of taking decisions to invest in R&D as well as for the goals of the elaboration of a competitive developmental policy of automobile companies.

The article is arranged as follows. Sections 1 and 2 include a review of literature. Section 3 presents the research methodology. The results are assessed within section 4. Final provisions are given in final section.

### 1. Literature review

One of the scientific-literature prevailing theories is the theory of a high role of competition in the formation of stimuli to innovations. The most important studies in the sphere were initiated by Scherer in 1967.

He went on with an empiric study wherein he assessed the nonlinear relationship between invention and market force based on data of 56 manufacturing industry groups. Inventive and innovative effort measured by the employment of technical engineers and scientists. Market force was measured by using a concentration indicator.

He came to the conclusion that technological vigor appears to increase with concentration mainly at relatively low level of concentration. When concentration of four companies exceeds 50 or 55 percent, then, additional market force does not probably result in more evident technological efforts and they can be lost.

Kamien (1975) worked out theoretical models wherein he described the nonlinear relationship between competition and innovations. His models suggest that companies maximize the expected current value of the project.

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At that, two expected patterns of mutual relations can take place. In the first one, as to profitable projects, the chosen development period decreases with increases of competition up to some mark. As soon as the competition becomes more intensive, the chosen development period becomes longer.

The second probable pattern is for less profitable projects. For such innovations, development period of the company increases along with the increase of a cooperation extent.

Kamien (1975), based on a mathematical model, arrived at the conclusion that intermediate competition is optimal (between perfect competition and monopoly) from the standpoint of high expectations of quasi-rent for the innovator. Thus, intermediate intensity of the technological competition is a strong stimulus to innovation activity.

Later on, the studies were developed by Aghion et al. (1997, 2005). The premise for the Aghion's model is the hypothesis that the technological leader and its follower make innovations, the leader's and the follower's innovations arising alternately one after the other.

Nonlinear relation can be explained as follows. If the competition level is low, then, stimuli to innovate arise for companies with equal potential. As innovation activity increases, competition grows as well.

But when the competition level is high, this brings up the phenomenon of laggard companies who have relatively less stimuli to innovate and, as a result, the average level of innovation starts to decrease.

It is important to note that nonlinear relation appears when the innovations are protected by exclusive rights. While nonexclusive rights cause an increase of stimuli to innovation in less competitive markets (Gilbert, 2005).

Competition is one of the most important factors of innovation. But there are other equally important factors that appear as additions or essential conditions for investing in research and development.

When it comes to commercial companies, investments in R&D mostly serve the companies' goals. Consequently, the higher profits, sales and the growth of the company will act as strong incentives to invest in R&D.

Schmookler (1966) gave a solid rationale for the statement that the proposed market size of a product is an important criterion influencing the range of activity in scientific research aimed at improvement of the product or reduction of the production costs. Schmookler also asserted that knowledge is not less

important for invention. On the one hand, there will be no need for invention without demand; on the other hand, it will not be created without knowledge.

Additionally, there are some recent empirical studies which have confirmed the effect of a company's size measured by sales divided on investments in R&D (Coad and Rao, 2010). Coad and Rao explain such influence by concern of company shareholders, managers and employees in respect to dispersion of revenue growth of the company.

Many authors carried out more detailed studies on the effect of particular factors. For example, Guidara and Boujelben (2015) studied how short-term goals of managers as to profit influence upon investment in R&D in conditions after approval of IFRS. The study was performed on the basis of data for France where companies considerably invest in R&D. As the result shows, managers tend to reduce R&D expenses to attain profit goals. Data were presented in the existence of threshold values and evidences of management of the real profit by charging expenses to R&D.

Limanli (2015) used the approach of generalized linear mixed model for complex survey design in order to find determinant decisions of R&D in Turkey from 2008 till 2013. The analysis shows that the size of the company has a nonlinear relationship with probable investment in R&D. Probability of investment in R&D grows with a growth of the size of the company and then tends to reduce. Export share in the total sales and governmental support are other important positive factors of investment in R&D.

Miltersen and Schwartz (2004) worked out a theoretical model for analysis of patent-protected R&D investment projects. In the model, in imperfect competition environment the participants contend for the development and advertising of a final product. Investments are made in uncertainty conditions and decisions are taken in view of not only factors which influence on the company's own decisions, but in view of factors which influence on decisions of other investors. Implementation of the model shows that R&D competition not only increases the production and reduces prices, but also reduces time for product development and increases a probability of successful development. On the other hand, R&D investment expenses increase and aggregated value of R&D investment projects reduces.

## 2. Research methodology

The goal of this research is to reveal the main factors influencing investment in R&D in automobile industry, as well as to explain the mechanism of such influence.

The object of research is major automobile companies of Germany and Japan.

The subject of research is the regularities in formation of stimuli to investment in R&D typical of major automobile companies.

This research is aimed, first of all, at the elaboration of some factors and evaluation of their effect upon investment in R&D. This refers to their detailed elaboration in respect to the Schmookler's and other scientists' argument on the effect that demand has on R&D investment. The research also suggests an evaluation of the degree of influence that specific factors actually have on automobile industry.

The authors propose that all the factors should be divided into two groups. The first one represents resources for investing in and manufacturing an innovative product. The second group represents positive and negative factors of the economic environment. They include internal indicators describing a company's financial results: net sales, net income, cars export, and return on sales.

The use of the factors in the analysis is governed by the fact that financial results from investments create positive economic expectations for investing in the future.

As the external factors, the following have been classified: GDP per capita, Lerner index, average wages in country, top 10% income share, internal market share, internal market share, and competitors' R&D investments.

The Lerner index and the company's income share in the market are indicators characterizing the competition level. Competitive suppression incites companies to escape it by investing in R&D.

The income share of the 10% corresponds to cash income of the wealthiest 10% of the population. The use of this indicator is due to the peculiarity of the market segment. Most car buyers are well-to-do people, so their income should probably have a significant effect on the demand, and correspondingly, on the investment in R&D. As an addition to the mentioned marker, we used the index of average wage in the country. Source of data of top 10% income share was WWID base, and an average wage in the country – OECD.

Information on R&D investment expenses was gathered on the basis of beekeeping reporting of Japanese and German companies. Reporting standards of two countries are different. Data of the analyzed Japanese automobile companies are represented according to US GAAP standard, while the same of the German companies are presented according to IFRS standard.

The said standards have similarities and differences. The R&D definition is substantially similar under US GAAP and IFRS. In both models, research costs

are incurred costs. Capitalized costs for development include the costs necessary for the creation, production and preparation of asset. They are amortized within a period lesser than the lifetime of a relevant assets or a production cycle. Basic differences reside in peculiarities of capitalization and presentation of development costs.

In addition, it is necessary to consider that accounting data are in a specific range determined by the company management structure.

In this connection, by comparison of values of investment in R&D of specific companies a relative share of R&D expenses in proceeds averaged for 10 years was used (refer to Figure 1). By comparison of regression models for countries, peculiarities of reporting standards and a specific nature of the management structure of companies were taken into account as other factors in the regression model.

#### 4. Research results

At the first stage, the investment activity of the largest automobile companies of Japan and Germany was compared, and the correlation between the group of factors and investments in R&D analyzed.

Volkswagen shows the largest investment amount in R&D among the companies researched (13,612 million euro in 2015). Toyota ranks second with investment amount of 7,017.84 million euro in 2015.

The growth of R&D expenses of Volkswagen Group may be explained by increasing expansion of the company after 2010. For example, at the end of 2010, they invested €6 billion in Chinese production plants such as in Foshan, southern China, and Yizhen, eastern China. That became real thanks to extremely successful issuing stocks with gain €4.1 billion. They acquired 90.1 percent of the shares in Italdesign Giugiaro S.p.A. (design and development company). It played a key role in forming the modern image of Volkswagen and Audi models. Also, the agreement with local partner DRB-HICOM to carry out vehicle assembly in Malaysia represents a further expansion of Volkswagen's operations in the ASEAN region. After that, Volkswagen laid the foundation for a new engine plant in Silao, in the Mexican state of Guanajuato. Starting in 2013, the facility will supply North American production sites with up to 330,000 engine units a year. On March 01, 2011, Volkswagen Aktiengesellschaft acquired Porsche Holding Salzburg which sold 565,000 new and used cars in Austria, Western and South Eastern Europe and in China. This boosted the Group's sales based on its key strengths of high efficiency and enormous earning power.

To compare the companies' investment activity in R&D we used a relative ratio of the share of R&D expenses in proceeds (refer to Figure 1).

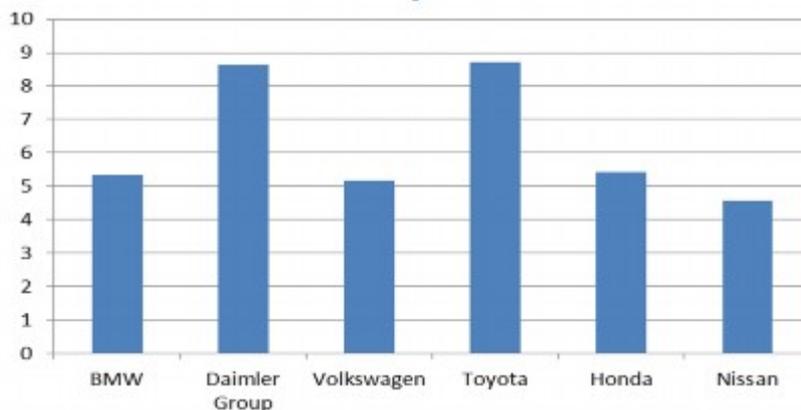


Fig. 1. Investment in R&D of automobile companies in percent of proceeds. Average value of the ratio for the last 10 years

The highest value of a relative amount of investment in R&D belongs to Toyota (8.7%) and Daimler Group (8.6%). This is explained by the more active policy of R&D costs and peculiarity of companies' management structure.

The detailed analysis of factors with linear and nonlinear relationship is represented within the regression model.

**3.1 Regression analysis.** To analyze the factors affecting investment in automobile companies' R&D, three companies out of the six largest companies chosen were established in Germany, and the other ones – in Japan. It is possible to assess significant factors causing increase (decrease) of investments in R&D by analyzing two markets separately with subsequent comparison of country differences and similarities within the period from 2001 to 2015.

In order to obtain quality results reflecting the particulars of Germany and Japan markets, we have compared the following three types of models: pooled regression model, panel model with fixed

effects (FE), and with random effects (RE). The choice was performed on the basis of Wald test (comparison of the first and the second model types), Breusch-Pagan test (comparison of the first and the third model types), and Hausman test (comparison of similarity of the second and the third model types). The factors have been introduced basing on their significance and contribution into the model quality in whole.

Considering the market of Germany, according to the tests performed, the following panel model with random effects has been chosen:

$$\ln(\text{R\&D expenses}) = \varphi_0 + \varphi_1 * (\text{Net sales}) + \varphi_2 * (\text{Net income}) + \varphi_3 * (\text{Total assets}) + \varphi_4 * (\text{Internal market share}) + \varphi_5 * (\text{External market share}) + \varphi_6 * (\text{Average wages in country}) + \omega_{it}$$

Coefficients of nonlinear regression factors have been obtained using a generalized least-squares method. The positive statistics value of chi square obtained in Hausman test ( $\chi^2(5) = 7.19$ ) gives evidence of correct model specification. The coefficient values obtained for the three models assessed are presented in the Table 1.

Table 2. Regression coefficients

Variable	pool	re	fe
Net sales	0.0084***	0.0084***	0.0068***
Net income	-0.0121**	-0.0121**	-0.0072
Total assets	-0.0030***	-0.0030***	-0.0014
Internal market share	-0.4630*	-0.4630**	0.1003
External market share	3.8298***	3.8298***	1.1915
Average wages in country	0.0001***	0.0001***	0.0001***
cons	-3.4788***	-3.4788***	-1.7324

Notes: legend: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

The average wage in the country, external market share, constant, net income and total assets have the strongest influence on investments in automobile companies' R&D in Germany at all reasonable levels of significance. Net sales and home market

share factor included into the model nonlinearly are significant at the level of 99%.

Analyzing the market of Japan, the following panel model with fixed effects has been chosen:

$$\begin{aligned} \ln(\text{R\&D expenses}) = & \varphi_0 + \varphi_1 * \ln(\text{Net sales}) + \\ & + \varphi_2 * \ln(\text{Net income}) + \varphi_3 * (\text{Total assets}) + \\ & + \varphi_4 * (\text{Export}) + \varphi_5 * (\text{Average wages in country}) + \\ & + \varphi_6 * (\text{Actives profitability}) + \varphi_7 * (\text{Top 10\%} \\ & \text{income share}) + \omega_{it} \end{aligned}$$

Coefficients of loglinear regression factors have been obtained using a generalized least-squares

method. The positive statistics value of chi square obtained in Hausman test ( $\chi^2(7) = 10.56$ ) gives evidence of correct model specification.

The null hypothesis on similarity of models with fixed and random effects has not been accepted. The coefficient values obtained for the three models assessed are presented in the Table 3.

Table 2. Regression coefficients

Variable	pool	re	fe
Net sales	-0.0312	-0.0312	-0.2136*
Net income	0.0440	0.0440	0.0377*
Total assets	0.0017***	0.0017***	0.0012***
Export	0.0025	0.0025	0.0053***
Average wages in country	0.0541*	0.0541*	0.0296*
Actives profitability	-6.0504**	-6.0504**	-4.1483***
Top 10% income share	16.1995***	16.1995***	13.7602***
cons	-7.3476**	-7.3476**	-4.6809***

Notes: legend: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

For the market of Japan, the variables of total assets, export, income share of the top 10%, constant and return on total assets became significant at all reasonable levels.

The net sales, net income and average wages in country are significant at the level of 95%.

For both economies, the growth of expenditures on R&D is connected with the growth of citizens' wages.

Among the German companies, the indicators of external market share and internal market share make the largest contribution into the fluctuation of the dependent variable. In Germany these indicators constitute the positive impulsive causes for investments in R&D.

In Japan the income share of the top 10% indicator makes the main contribution into the fluctuation. This means that investments in R&D grow considerably along with the growth of the income share of wealthy people.

The negative contribution of the return on total assets and sales revenue indicators on the fluctuation of the dependent variable is explained by the fact that the decrease of these indicators creates a suppression effect promoting managers of the company to implement more active competitive actions.

### Conclusion and recommendation for further research

The results obtained may contribute to the theory explaining the formation mechanism of investment

strategy and policy elaboration for competition and innovations development used by automobile companies.

Automobile companies form oligopoly markets of differentiated products. These are the markets with the highest potential of competitive activity, where innovations play a crucial role in economic development and obtaining success.

The most positive influence upon investment in R&D in Germany is made by the company's share in the external and internal market. At that, influence of the external market share on a variation of investment in R&D is much stronger than the internal market share. Probably, one of the explanations is that the analyzed German automobile companies have a greater income from export than from sales in the internal market. Competition between automobile companies for a market share is one of the basic stimuli for investment in R&D.

In Japan, one of the basic positive factors of investment in R&D is a share of the most well-to-do people in Japan. Probably for Japanese companies a demand factor is decisive in the formation of R&D expenses policy.

We believe a promising area of future research might be to identify the specific factors of investment in R&D in other sectors to better understand the patterns of policy-making for R&D in large firms.

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