Federal State Budget Educational Institution for Higher Education

THE RUSSIAN PRESIDENTIAL ACADEMY OF NATIONAL ECONOMY AND PUBLIC ADMINISTRATION UNDER THE PRESIDENT OF THE RUSSIAN FEDERATION

SCHOOL OF PUBLIC POLICY

Chair of International Management

Qualification: 38.03.02 Management

Master's Degree Program: Global Governance and Leadership

WORK TITLE:

«The Advantages of Research and Development and innovation in competitive markets»

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Moscow 2020

CONTENT

INTRODUCTION

To begin with, the object of my paper's research is a process of Research and Development and innovations in the sector of IT companies, while the subject is the effectiveness of the above-mentioned process, including its evaluation system.

The central objective of the paper is a provision of recommendations aimed at the increase of the level of effectiveness of R&D at IT companies.

The goal forms a number of following tasks:

1. the analysis of the current situation in regards to investments in R&D and innovations by IT companies
2. data provision showing the current success rate of innovation projects
3. presentation of unsuccessful and abortive famous cases of innovation projects
4. the analysis of R&D process evaluation system
5. the analysis of companies' experience regarding improvement of R&D efficiency level.

The methodological basis of the research is represented by comparative, descriptive, and logical methods that relate to general scientific methods. It is also important to note that within the empirical part of the presented study, synthesis and analysis methods prevail.

The structure of the paper is defined by the main goals and objectives and consists of an introduction, three chapters, conclusion and a list of references.

The first part of this paper can be seen as a description of the current situation regarding expenditures on Research and Development and its effectiveness.

The second chapter shows a complication related to R&D and innovations providing key threats of Research and Development (both internal and external). Also, there is a number of big companies and their disastrous failure cases of innovative projects as an explanation of their low success rate.

The last but most important part is a proposition of recommendations in order to increase success rate of such projects and in order to increase the whole R&D and innovations effectiveness, which implies a division into a number of cost-efficiency drivers as well as productivity-boosting ones.

CHAPTER 1 Why do companies of computer software sector are willing to invest in R&D?

1.1 Key principles of R&D

The term «R&D» or «Research and Development» implies scientific activities undertaken by companies to innovate and introduce new products and services. These works are aimed at obtaining new knowledge and applying it in practical life.

For companies which are familiar with «Research and Development» in management and, therefore, which are focused on such development, it means being advanced in creating new types of products and promoting them on the markets.

Most people from the former Soviet Union know there were similar ventures in the USSR: widespread scientific research institutes and design bureaus which carried similar developments. Generally, it was common in the military sector, but also in fundamental areas of science and a number of areas of the national economy. In modern times, many companies also use «Research and Development» as an important element of their strategy for development and being different from competitors.

Nevertheless, this strategic instrument has a couple of troublesome areas. Here I am going to mention the most superficial one: I mean the cost of such projects and their period of payback. Modern business principles do not allow even large companies to spend too much time on such developments, their implementation, and promotion. That is a problem even for large corporations, famous brands and network marketing companies. Does it make sense to consider small and medium businesses?

It goes without saying, if company treats «R&D» an important element of its overall future development, it does not skimp on such scientific projects. Usually they create their own research centers, attract leading specialists and scientists on a permanent basis as well as numerous temporary consultants. They provide all the conditions, equipment and opportunities required for research, experimental development and industrial serial development.

Let me mention a couple of superficial examples of R&D surrounding us. Automotive companies' manufacturers of automotive components altogether create new car models. Food companies in cooperation with manufacturers of food components and raw materials constantly offer their consumers new types of products. Thousands of computers, smartphones, tablets and other gadgets are constantly developing, and this is also a consequence of ongoing scientific research and development projects. These are prime examples of R&D and such examples can be given in any industry, in many areas of commercial and non-commercial activities of enterprises.

Obviously, the most important element of the R&D strategy is the speed of research and development. Key objective is not just to get result, but to do it before competitors, combining with a very important element of every production business - the protection of intellectual property. In this way company does not throw money away and developments are not used with impunity by competitors who are eager to copy and offer to consumers products invented and designed by more successful business rivals.

I have already mentioned that in large corporations, R&D is created not only by individual departments, but also by entire enterprises and research institutes. Medium and small companies can create R&D departments, or they can implement R&D functions in conjunction with marketing or productive divisions. In other words, small companies may have a «research and development» function, but usually they do not have a separately dedicated division in the organizational structure for this purpose. Regardless the form of implementation, the R&D function allows the enterprise to grow, evolve and expand by creating new types of products or services.

In R&D usually the project organization of work is used. Each new product or service is a separate project. Projects may overlap or even merge into so-called megaprojects. In order to manage such projects or megaprojects, it is convenient to use project management methods and project organization of work. In each project, a project Manager can be appointed to develop a project plan, attract performers, create and protect the project budget.

Unlike ordinary processes, which are one of the most modern forms of enterprise management, projects have a limited time of existence. The project must always be completed, whereas the process can exist within the company for unlimited time. This organizational form and usage of project management mechanisms in most efficient ways make it possible to achieve project completion with a positive result. The project itself is not already a success. Only a project perfectly completed in time and within the planned budgets can be considered as success.

Despite the complexity of the organization of such scientific developments and innovations, despite the costs associated with designing the future, many companies, including medium ones, frequently use R&D as a competitive tool. They design not only new products, but also completely new types of services, which is also important in the competition for the market share.

1.2 New global trends at investing in innovations

Nowadays economic instability forces even market leaders to reconsider their investment strategies. Investment in R&D is not an exception. During the crisis of 2008-2009, European companies, as well as Russian ones, reduced their Research and Development spending and created global trends which are still noticeable today.

In 2008, Russian analysts predicted another drop in economic indicators. Businesses have almost refused the idea of investing in new technologies. According to the «Expert Rating Agency», both private and public investments in R&D in Russia have fallen by 5% since the beginning of the year. The private sector showed especially great drop in investment indicators. Even before the crisis, an average volume of innovation spending by large Russian companies did not exceed 0.5% of revenue, and after 2009 it decreased to 0.1% of total company revenues (considering that revenues themselves were falling, these figures look even more depressing).

Considering Western countries, economic instabilities occurred about a year later. So, since 2009, the world's largest giants have also begun to reduce their investment in R&D. According to a McKinsey study, held in 2009, approximately 40%

of the world's top managers said they had to reduce R&D spending, and about 30% managers decided to reduce the number of R&D projects planned for that year. However, a number of representatives of major Western companies said that they did not intend to reduce investment in R&D, and some of them even planned to increase spending in the midst of the crisis (figure 1.2.1 below). So, Figure 1 shows that expenditures on Research and Development and innovations are not affected even by international crisis (Great Recession during the late 2000s).

As a result, in the West, private sector investment in R&D declined only in 2009, and a year later, in 2010, there was a steady growth again (figure 1.2.2 below).

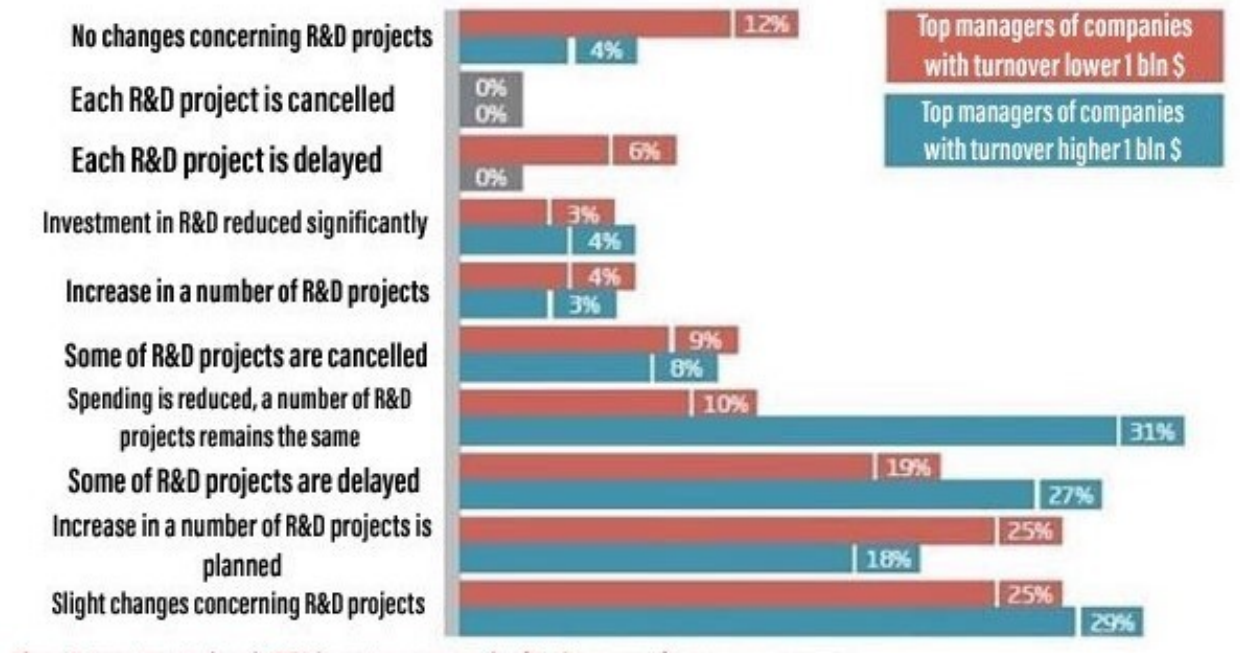

Figure 1.2.1 Investment plans in R&D in Western companies (% of managers)

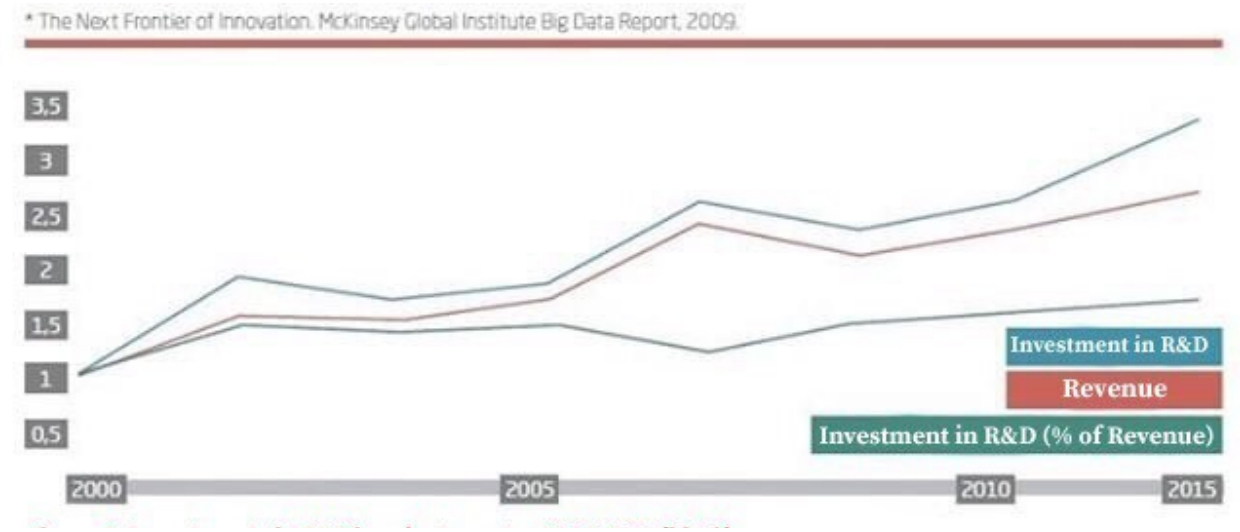

Figure 1.2.2 Investments in R&D in private sector 2000-2015 (bln $)

I believe that most of the world's major corporations can’t simply cut their R&D spending significantly. Let me take, for example, any major corporation in software sector: Google, Apple, IBM or Microsoft. A significant reduction in R&D budgets, even in a situation, where the overall market indicators are falling, is a «suicide» for such companies. I mean they already have a well-established cycle of new product development and they simply can't stop it. Otherwise, they risk violate their obligations concerning new products (this may be followed by legal proceedings and additional costs) and risk find themselves with much smaller number of loyal clients. Moreover, a number of large companies treat such periods of instability as an opportunity to outperform their competitors and occupy the vacant market share at minimal cost. Using this strategy, investment in R&D is a primary tool.

During years followed by crisis, a number of key principles, tactics and strategies related to spending on R&D have been changing. In 2009-2014 the approach to this type of investment

in the West has experienced significant changes. First of all, companies have become more conservative. So, according to a McKinsey survey, in 2009, 31% of Western companies with a turnover of more than $1 billion began to focus on projects with the shortest payback period, freezing, delaying or even cancelling most of long-term projects. 14% of companies emphasized their R&D towards lower-risk projects. More than 70% decided to create fundamentally new products and services that would meet the changed needs of their customers in the era of crisis. At the same time, long-term projects and the development of more or less vague products were postponed.

Secondly, most market leaders have revised their policies in the field of recruitment. Before the crisis, the rotation of specialists in knowledge-intensive areas was extremely high. If, for example, Google needed a unique specialist in mathematical sets, the company could afford to «buy» him on the market, paying 2-3 times more than its previous employer. However, since 2009, according to McKinsey, 27% of large Western corporations have frozen their budgets for expanding the staff of specialists in R&D departments. Approximately the same number of companies has taken a course to grow such talents inside the company. Three years later, when the economy began to recover, 35% of respondents reported that they sharply reduced the scale of «purchases» of specialists in the foreign market. A new recruitment strategy that emerged during the crisis has become a primary one.

a) The Asian trend

It was the period of 2008-2013 that formed the global trends that we can see today in the field of Research and

Development. The first of trends is a large amount of investment in Asia. Before the crisis of 2008, the United States was the leader in attracting investment in R&D (in 2008, the total budget for R&D of American companies was $532 billion; $215 billion was invested domestically). Since 2009, the situation started to change dramatically. According to «Bloomberg», from 2009 to 2015, a number of spending on R&D of American companies was still increasing, but the main growth came to foreign companies, and first of all – to Chinese ones. In 2015, the US invested about $60 billion in Chinese scientific research projects. At the same time, investment in R&D in China itself began to grow explosively: according to «Capital IQ», the growth about 60% from 2009 to 2015. Less significant, but still noticeable growth in R&D investment is observed in this period in India: by 2015, the country was able to attract more than $30 billion. Most of this money came from domestic market players and from the Chinese, British and Americans companies.

The primary reason why Western companies have started to move their Research and Development spending and departments to Asia is generally clear. There were same reasons that prompted major market players to move their production to China, Korea, and India in the mid-1990s. I mean cheap labor, «softer» tax policies of the authorities, lower operating costs, and huge potential for Asian markets. One of the most striking examples in this area is the American industrial giant «Caterpillar». During the crisis of 2009, the company opened a new Research and Development center in the Chinese city of Wuxi, the center of Jiangsu province. They were sure that China was a huge market experiencing a construction boom, so it was

important for to open a research center that would better understand the needs of local consumers. But the issue was not just about the «cultural» specifics, which was better understood by Chinese employees of the new center than by the Americans. The main reason was that the center was opened just across the street from the Chinese «Caterpillar» factories. One of them started working in 2006, and the other two were launched a couple of months before the center was opened.

Geographical proximity helped the company to speed up an exchange of information between enterprises and the R&D division and to make it less expensive. In addition, the center was located next to the Caterpillar Asia Pacific Proving Ground – the company's experimental site, where all the products were produces and being tested for Asian consumers (not only Chinese, but also Korean, Japanese, Thai and so on). This also reduced costs and time spent on information exchange and product development.

I have read the company’s R&D report where it was told that all the R&D products at Caterpillar were divided into three major categories. The First category was “products that are one cycle away from the current one and have a chance to appear on the market in 5-10 years”. This type includes mainly engineering equipment. The second category was the company's «existing products, which were subject to modifications and improvements». And, finally, the third one – «products that could be reduced at cost and improved at reliability».

At the same time, each research center of the company, regardless of its location, participated in all three categories of projects or at least at part of them. For example, «Caterpillar» is

currently actively developing a new generation of compressors. They are planned to be released primarily to the US market, so the entire product development cycle is managed in the United States, Illinois. Employees of the American research center conduct measurements and analyses, send the data to Chinese department and by the morning receive a complete analysis of the results from their Chinese colleagues. I would say it is quite reasonable to use time difference in such an efficient way.

b) Student Fraternity

Another global trend that emerged in the field of R&D during the crisis is the activation and reinforcement of links between major market players and the educational environment and universities. I would say that in most cases this trend is a perfect complement to the Asian trend. In other words, Western companies have begun to show increased interest not just in universities, but in universities in Asian countries. For example, between 2009 and 2011, «GE» («General Electric») was investing more than $4 billion in Research and Development every year (including $800 million invested in new healthcare products or «General Electric Healthcare», «GEH»).

GEH's Scientific Research center is Munich. Here employees of the corporation are engaged in Research and Development in the field of medical products. Back in 2007, the company launched an additional Research Center in Bangalore, then, in 2009 a program of cooperation with the local Polytechnic University was started. Small by Western standards, but giant by Indian standards grants were allocated for students engaged in medical research. As a result, the MAC 400 was released - a portable electrocardiograph with the market price of

$800. Comparing to the similar analogues produced by the same «GEH» to the markets of Europe and the United States with a cost varying from $2 000 to $10 000. Furthermore, in 2010 at the same Bangalore center, with the involvement of University students, the MAC 400 was finalized with a price of $500.

The new product started selling unbelievably well, especially in emerging markets. According to Vijay Govindarajan (senior innovation consultant at «GEH») the crisis has caused innovation processes to flow in the opposite direction. If 10-15 years before crisis technologies and innovative solutions came to Asia from the West, then in the second decade of the XXI century, the opposite trend has clearly developed. Asia has started to create its own innovative solutions and technologies with a lower cost, which are used all over the world including in Western countries."

c) Pragmatic approach

Finally, the third significant global R&D trend emerged during the crisis and recession of 2009-2011 is related to the relationship between large companies and their suppliers. The easiest way to show the dynamics of these relationships is to use the example of the Japanese Honda Corporation. Despite the rapidly growing crisis processes in the global economy, according to the Booz & Company report, in 2009 Honda Company was one of the Top 20 largest innovative companies in the world. The corporation invested $5.6 million in Research and Development. Considering the amount of money, it was 4% less than a year earlier – but taking into account a percentage of the company's revenue, the figure increased by 6%. Honda, like most Japanese companies, builds its relationships with suppliers on

the «Keiretsu system». It forms a conglomerate of companies, where various shares belong to Honda itself. It looks more like a «mother-daughter» than a «customer-supplier» relationship. Within the companies using the framework of Keiretsu, technology exchange between the parent company and its subsidiaries was common. So, Honda was not an exception in this sense. The company actively sponsored the development of new materials, spare parts, and technologies that were later to be produced by its suppliers. However, this system that has been established for year was also changed by the crisis.

In short, Honda has become more pragmatic in a relation to working with suppliers. First, the company has started the promotion and stimulation of competition. For instance, the supplier X produces spare parts for Honda in Japan. Previously, this meant that the same supplier would produce spare parts for the company in the United States, the United Kingdom, and Southeast Asia (if the capacity of production allowed). Right before the crisis, Honda management realized that this approach makes the relationship with the supplier stronger, the quality is becoming more and more predictable regardless creating more risks – concerning both price and technology. In 2009, the company started movement away from the principle of «one part – one supplier». Honda began to create competition among its suppliers. Honda choose those suppliers who best meet the companys needs according to 5 criteria: quality, price, logistics, development and management (or «QCDDM» - Quality, Cost, Delivery, Development, Management).

Second, the company has increased the exchange of knowledge and expertise with its suppliers, while reducing

overall spending on Research and Development on the supplier side. Previously, it was considered like a normal practice for Honda to send own specialists to work on the supplier companies' sites. But after 2009 this practice has become mandatory. Today any Honda supplier is required to send a group of R&D specialists to the company's factories at least once a month, and Honda's R&D specialists are required to work for several months in the Research departments of supplier companies. Moreover, earlier the exchange of knowledge and technology between suppliers themselves was not encouraged in Honda. However, now, despite the promotion of competition, the company has stepped up the transfer of best practices from one supplier to another. The logic here is simple and has a special Japanese specificity: if a solution is found, it does not mean that it cannot be improved and refined, and the best way to improve one is to involve as many people as possible in solving the problem. Honda management believes this innovation, like any other strategy, requires staying pragmatic and forward-thinking. The logic was that crisis will end sooner or later, and the trends that were set in motion as a result of economic instability will remain for a long time – at least until the next crisis.

Talking about Russia, I can say that from 2010 to 2014, the costs of Russian enterprises for technological innovations increased from 349.8 to 762.8 billion rubles (2.2 times more), while the share of innovative products in the total volume of goods, works and services produced in the Russian Federation increased from 4.9% to 8.2% (almost 1.7 times more). Russian exports increased from 6% to 9% (1.5 times more). This data was presented at the Gaidar forum in January 2016 by Anatoly

Aksakov, head of the state Duma Committee on economic policy, innovative development and entrepreneurship. According to the Committee, the most active technological innovations were introduced by enterprises working in the area of production of electronic and optical equipment (27% of all enterprises in the industry), production petroleum products (23%), chemical production (21.4%), production of vehicles and its equipment (19.4%).

So, most of private companies are not really interested in developing their R&D. The overall number of companies that have built their business models based on R&D is extremely small – according to the “HSE Institute for statistical research and knowledge Economics”, it is less than 5% among industrial enterprises. The largest expenditures on innovation can be seen at large state corporations. Thus, “Rosatom” spent about 28 billion rubles on R&D in 2014. As a result, according to the company's annual report, its specialists have received 1,129 patents. In the same year, “Gazprom” spent a record high amount of 10.82 billion rubles, and the group's companies received 218 patents.

In 2016, Russia ranked 12th among the world's innovative economies in the innovation index compiled by Bloomberg (14th place a year before). The index evaluated seven indicators: R&D expenditures, productivity, concentration of technological companies in the national economy, prevalence of higher education, value added of goods, number of registered patents, and number of researchers. The first place in this ranking was held by South Korea. It is followed by Germany, Sweden, Japan and Switzerland. The top ten most innovative countries also

include Singapore, Finland, the United States, Denmark and France.

1.3 Why do companies of computer software sector are especially interested in investing their money in R&D?

It is hard to overestimate the importance of scientific researches, developments and innovations as the whole in the Information Technology sector, which involves companies that produce software, hardware or semiconductor equipment, companies that provide internet or related services etc. That is why spending on R&D for leading companies working in the IT sector is completely undeniable. Such corporations have a huge inventory of intangible assets. In fact, intellectual capital for the IT companies is one of the main factors in determining the market value of the company.

There is a study called «Global Leaders of Innovation», which analyzes the spending of 1,000 of the world's largest public companies in terms of investment in researches and innovations. The annual studies have been conducted for more than fifteen years. They show exactly how investment in innovation is linked to a long-term growth strategy and confidence in the future in the face of increased spending on R&D in each region and virtually almost each industry.

According to a number of last annual researches, globally, spending on innovations and R&D in the IT sector companies has increased in all regions, especially a “double-digit growth” can be seen in China (+34%) and Europe (+14%), while North

America and Japan experienced slightly less dramatic increase (+7.8% and +9.3% respectively).

At the same time, the overall knowledge intensity — the ratio of R&D spending/ sales — remained at the quite high level of 4.5%.

This year research was a part of an industrial comparison of performance and investment in innovation over five years. As a result, 88 companies from different countries and industries received the status of high-performance innovative companies. These companies outperformed competitors in their industry groups in seven key financial indicators over five years, even while their costs of R&D spending as a percentage of sales were below the industry average.

The set of seven financial indicators includes revenue growth, increased market capitalization, operating margin, gross margin, operating profit and gross profit, and total shareholder income.

These 88 high-performing innovative companies in the period from 2013 to 2017 showed the same indicators of operating and gross margins as other organizations included in the study «Global innovation leaders», but the growth of sales and market capitalization of these companies was almost 3 times higher. Most successful IT companies at the top of the ranking outperformed other market participants at least twice in all other analyzed indicators.

All 88 high-performance innovative companies demonstrated the following common characteristics:

- Strategic consistency: 77% of the fastest-growing IT companies reported a high level of consistency between their

innovation strategy and their business strategy. In comparison, the indicator of a group of corporations who did not increase the growth rate was 54%, and in the group of companies showed a slowdown, there are only 32%.

- Culture: 71% of IT corporations who showed faster growth in their income relative to competitors said that their corporate culture is aligned with the innovation strategy, compared to 53% of companies who did not increase their growth rate, and 33% of respondents whose growth slowed.

- Role of management: 78% of companies whose revenue growth exceeded the average one within the industry competitors indicated that management fully or significantly supported the strategy for investment in R&D and innovation, compared to 62% of firms who did not increase their growth rate, and 53% of companies who showed a slowdown in growth.

In terms of geographical distribution, the resulting list of companies reflects a consistent significant growth in the number of companies from China — from 3% in the first survey in 2007 to 17% in the last year survey.

European companies also showed significant growth — from 18% in 2007 to 30% in 2018. In North America, the number of high-performing innovative companies decreased by 45%, and in In Japan, such companies were less than 8%.

Also, out of the more than 1,000 companies whose performance was analyzed over 3 separate five-year periods ending in 2007, 2012, and 2017, only two confirmed their status as high-performing innovative companies over the entire 15-year period. Both of them are representatives of the IT sector.

Among other main results of the study, the following can also be noted:

Amazon has become the leader in R&D investment for the second year in a row. Siemens is once again among the world's top 20 companies in terms of R & d spending.

Apple regains the top spot in innovation, beating Alphabet, and Netflix is among the top ten most innovative companies for the first time.

In 2018, the information technology and electronics account for 40% of global corporate Research and Development spending.

It is also worth to be mentioned, that among top ten most innovative companies there are 7 representatives of the IT sector: Apple, Amazon, Alphabet, Facebook, Microsoft, Samsung and Intel.

The amount of expenditures on Research and Development innovative projects by IT companies such as Apple Inc. (Figure 1.3.1) and Alphabet Inc. (Figure 1.3.2) is attached below. I have examined about a dozen IT companies' investment reports taking into account large market leaders as well as medium companies in IT sector, but most of them showed quite similar view:

- The amount of R&D spending is steadily growing
- The number of projects and their spending are not affected neither by local nor by international crises

- The further – the higher is a percent of company's revenue spent on R&D and innovations

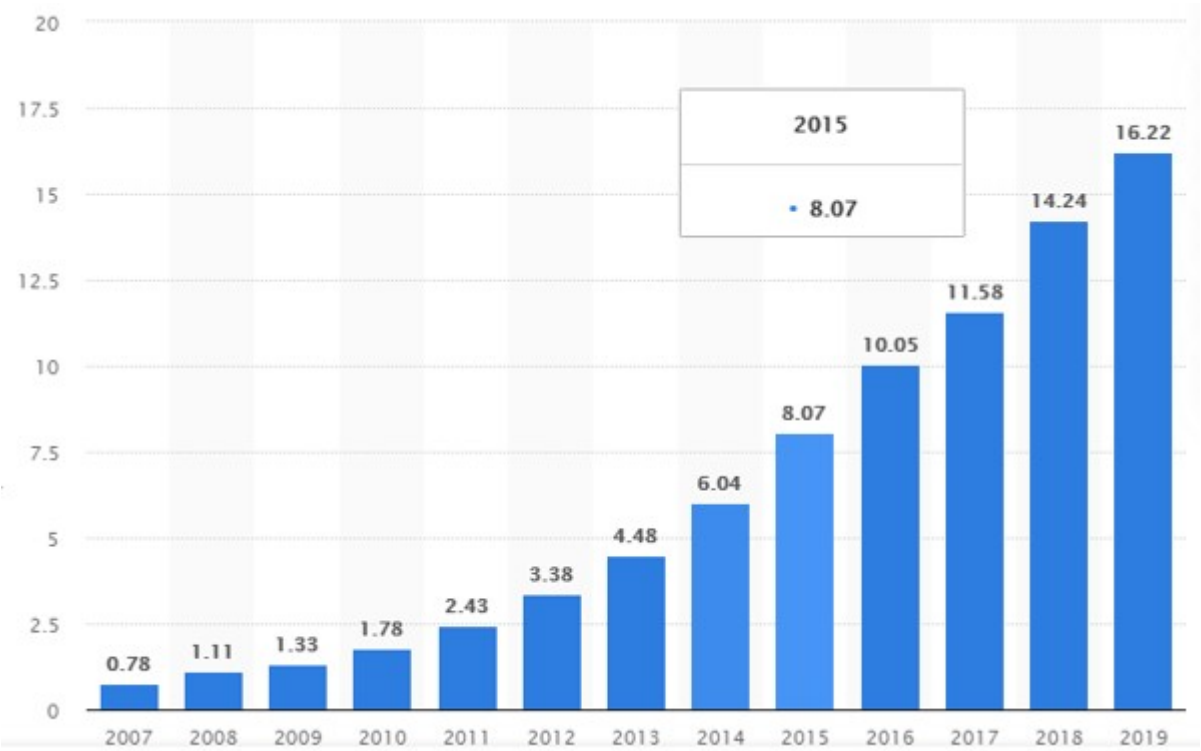

Figure 1.3.1 Apple Inc. Expenditure on R&D projects, 2007-2019, billion $

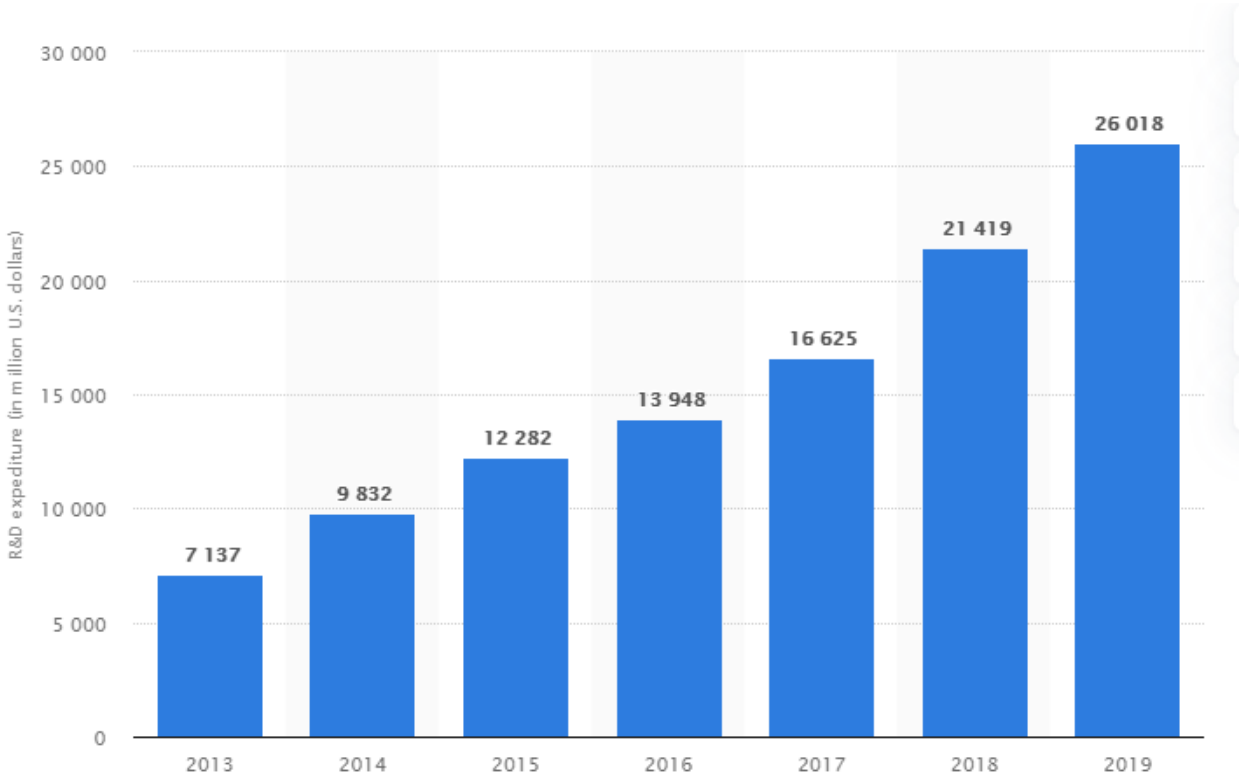

Figure 1.3.2 Alphabet Inc. Expenditure on R&D projects, 2013-2019, million $

Once again, each company representing IT sector, regardless its size, number of employees, market value etc. is primarily interested in development within the field of researches and innovations. Obviously, each company is eager to get a successful invention, discovery or some kind of breakthrough regardless its industry. However, I believe, today, during the century of technologies, the closer company is to the software/hardware products, internet provision/services or semiconductor equipment industry, the closer it is to revolution and numerous innovations.

Regarding expenditures on R&D and innovations in IT, the final statement is also quite obvious: Research and Development spending is currently critical for large corporations, especially for such companies in IT industry (Figure 1.3.3). Moreover, such

spending is not affected even by international crisis (Great Recession during the late 2000s) while the amount of such spending within the industry is steadily growing from year to year.

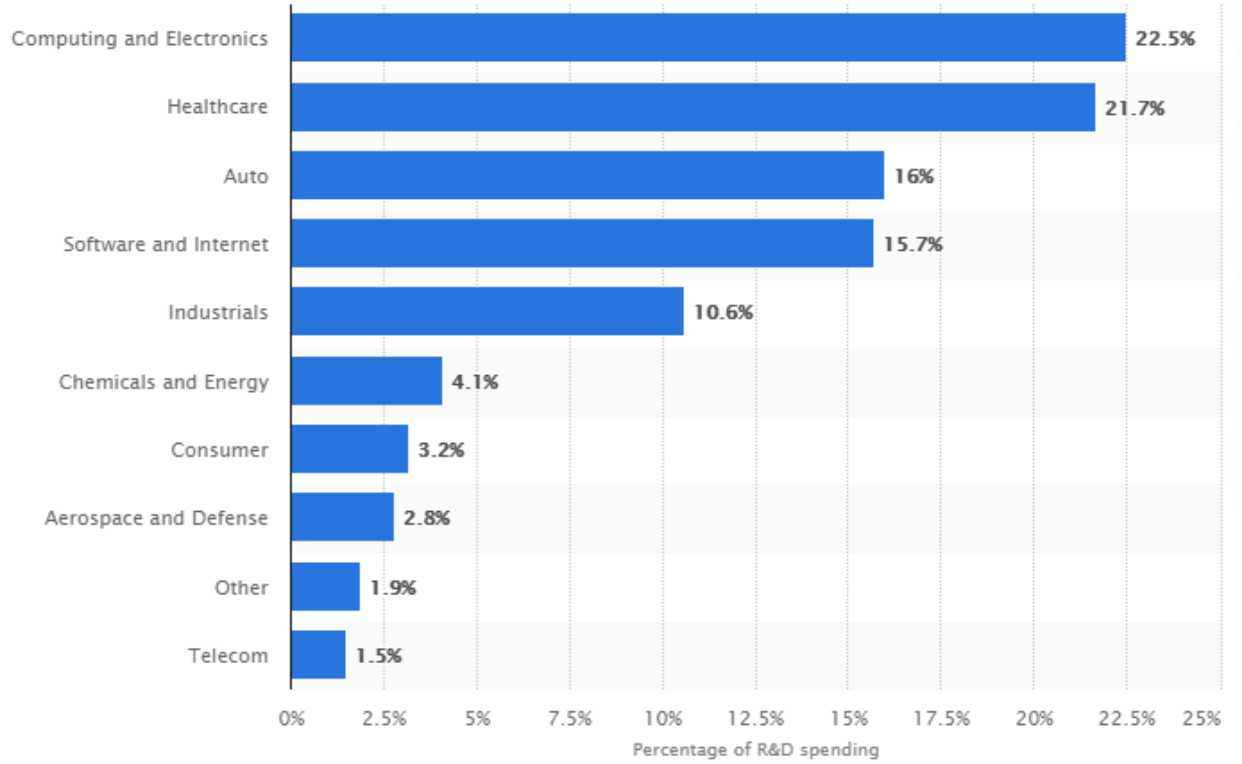

Figure 1.3.3 Percentage of revenue spent on R&D by industry, 2018

Nevertheless, a large volume of such spending on innovations still does not guarantee a high success rate of R&D projects. So, the next chapter represents the analysis of success rate of such projects providing examples of famous innovative projects.

CHAPTER 2 Fails and drawbacks of R&D and innovations (at software companies)

2.1 Low success rate in R&D and innovations. Industry statistics and cases

Thereby, development of innovative Research and Development departments and so-called «investments in the future» of a company are becoming fundamental and inevitable expenditures. Unfortunately, a great number of organizations cannot afford such significant spending on innovations. Moreover, even if an organization manages to allocate money for such investments, one more issue arises: most of R&D departments work not as efficiently as it was expected. That is a reason why this chapter analyzes effectiveness of such investments in innovations.

According to the report from the PMI (or Project Management Institute), only 14 percent out of all Research and Development projects in IT sphere fail. It seems like other 86 percent of projects should be successful. Unfortunately, this is not the case. That number of 14 percent represent only complete utter failures - most of projects did not fail outright. Nevertheless, 31 percent did not meet their primary target objectives, at 43 percent of cases the initial budget was significantly exceeded and almost half of them (49 percent) were slow and tardy. More detailed at the Figure 2.1.1:

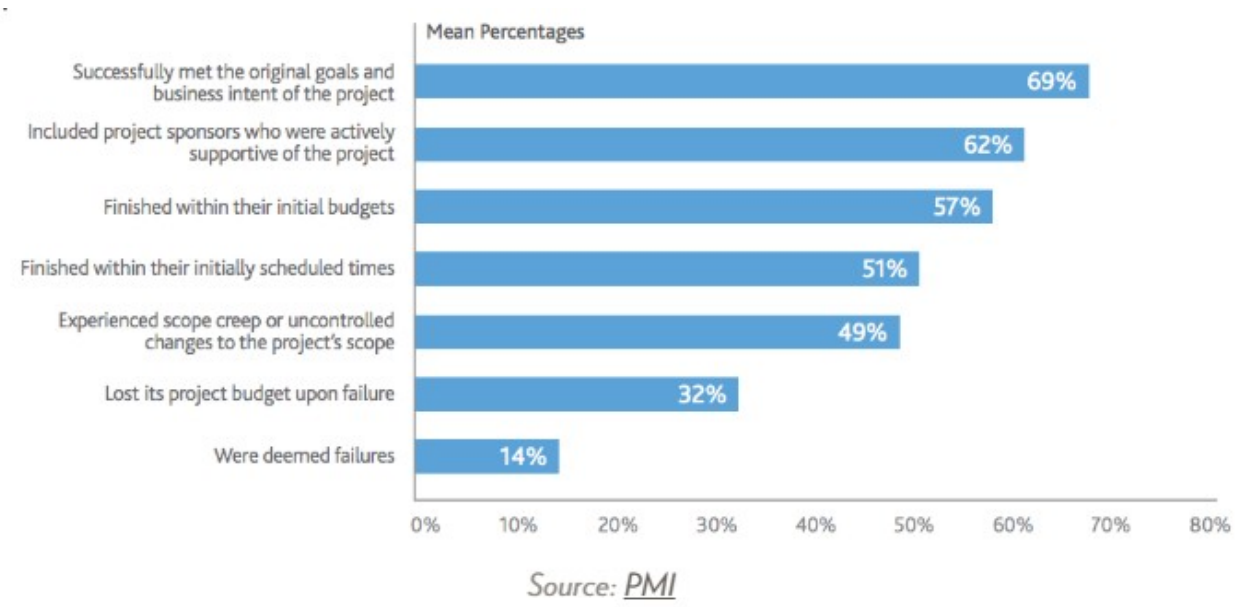

Figure 2.1.1 Success rate of R&D projects in IT industry, 2017

It is worth to note that abovementioned data mostly relates to the advanced and progressive international companies and market leaders. Most probably, in regards to more modest and frugal organizations the overall situation is rather different.

In order to get the full picture of the current situation regarding expenditures in R&D and innovations and its real effectiveness I would like to refer to the report called «The Impact of Business Requirements on the Success of Technology Projects» provided by IAG Consulting.

Summarizing the whole report, I would mention a number of most important statistical facts:

- 70 percent of companies are more likely to have quite an ordinary «below the average» project or even a complete failure.
- Organizations with medium business analysis capabilities have three times as many projects failed as successful ones.

- On average, companies of Information Technology sector take over 180 percent of target time and consume in excess of 160 percent of expected budget, while provide under 70 percent of the required functionality!
- Approximately 40 percent of the budget allocated for the R&D project is usually consumed by poor requirements of a software company.

The reason of such a poor state of affairs is rather superficial: usually the level of required competency is much higher than the existing within the R&D department employees one. In my humble opinion, this situation mostly relates to medium companies (especially representing software sector) and can be described as: «average companies use average specialists in order to succeed average projects» while leaders of IT industry have much more positive circumstances and most probably succeed in such projects much more frequently.

Then let me go back to worldwide known corporations and provide a number of recent cases which lead to great financial losses.

One of the most widespread examples of such disastrous projects is a *Fire Phone by Amazon.* In the summer of 2014, the company launched a new promising product — Fire Phone. However, the project has become one of company's biggest misfires. Right after a debut at the top spot of Amazon's retail charts, things quickly spun out of control. Overall, according to company's reports, the Fire Phone sold approximately 30 thousand of units during the first month after release. One more outstanding fact concerning this case is the reduction of the price of the Fire Phone down to 99 cents per unit. Unfortunately,

even such a prodigious price reduction did not make people to start buying the new phone. It was more than enough to put Amazon off the whole project of Fire Phone and to end the permanent production of these smartphones just a year after release date, in September 2015. Nevertheless, even more upsetting for Amazon was the fact that the company has instantly lost more than $170 million. In order to realize the volume of the loss, it is equal to the budget of the first “Guardians of the Galaxy” movie. In my humble opinion, the primary reason of such a great loss is rather obvious: the company has overestimated the product – Amazon has put Fire Phone at the top of sales charts and has produced too many units of the product before the release date just because of too much of confidence in the product.

One more example failed projects is even more famous – *Galaxy Note 7 by Samsung*. It has been one of the most discussed technological failures of recent years: new 7th model of Galaxy Notes produced by Samsung has experienced numerous cases of phones explosion. As it turned out later, it was suspected to be battery issues all along: the company had a couple of issues related to phone’s battery during the process of Research and Development (batteries were smaller at one corner, causing the higher likelihood of short circuiting) as well as during production process (there was a third party provider of batteries, “Amperex” Technology Ltd. Their batteries were found to be incorrectly welded. In September 2016 Samsung was forced to suspend sales of the new promising product due to numerous reports of explosion right in the hands of users. The company has ordered a global recall of two and a half million

units of devices, hoping that such measure is going to prevent the more significant issues for the brand.

Fortunately, there were no fatal accident because of Samsung phones explosions. Nevertheless, the company has experienced a number of problems which lead to additional corporate expenses: trials and court proceedings, the ban on all US flights due to fire hazard. As a result, Samsung, whose sales indicators were growing from year to year, has experienced a 2-percent drop in sales according to the annual company's report. Moreover, the reputation of Samsung as a leading innovative technological company has suffered right after first announcement of the explosive battery. Taking into account the fact of fast-growing competition within the market of smartphones (Apple was about to announce new iPhone 7, Google as stated it has started to develop its own smartphones), the level of credibility of Samsung company as a smartphone pioneer was also significantly affected. However, it is not only a reputation that have been affected. According to numerous estimations, the first recall has cost the company about $2 billion including the cost of phones replacements and significant of in the company's share price.

Thirdly, I would like to combine two cases of the innovative project failures: Google Glass and Apple Newton. I have interconnected these two cases because of quite similar issues and failure causes.

In 2012 Google has announced its promising innovation – Google Glass. The device was supposed to provide you with mobile communication, geolocation, voice-controlled and transmitted sound through the bone. Rather innovative, isn't it?

Undoubtedly. However, it didn't work out. First of all, price was innovative as well - $1500, three times higher than flagship models. Second reason was a number of privacy issues: Google Glass could shoot everything that came into view as a video without being noticed. It is not known whether the owners of glasses would find loopholes in the laws, but there were numerous rumors that the glasses would fall as illegal devices. Actually, it's not surprising. Obviously, this project is not an exception – it caused a huge financial loss for the company. Nevertheless, today Google is developing a new generation of Google Glass which are going to be used more in professional sector. Also, it is worth to mention that this project gave an impetus to the development of the whole modern VR-glasses industry.

In its turn, Newton, pocket personal computer, developed by Apple Inc. was supposed to become a pocket mini-computer capable of recognizing stylus handwriting. This was a central feature and a central issue of the product same time. Taking into account the late 90s, the price of product was similar to Google Glass: $1000. However, a system of written text recognition was a hell of a mess. So, why did people need to pay $1000 for a device that doesn't do its main task? Moreover, the size of Newton was not for “pocket”. As a result, it is not too portable, rather expensive and poorly working gadget. Apple was eager to make a breakthrough with Newton, but the company has evidently rushed to the market the unfinished device.

In order to realize the volume of financial losses, I have also examined annual Research and Development Expenditure reports of leading IT corporations. As a result, only in 2019 due

to innovative projects failures and delays Apple Inc. has lost more than $5 billion; Microsoft has lost even more than $6 billion. There is a great number of such examples and I am not going to mention a lot of them.

However, I will highlight a couple of core *internal reasons (threats)* why do project fail so often and why do companies still lose millions and billions of dollars due to project failures.

a) Wrong decision-making

Research and Development management often sets wrong course within innovative projects or during the process of selecting ideas in regards to the promising products. Obviously, wrong decisions affect a great number of aspects such as ideas prioritization, product strategies for new products, choice of development options, etc.

The reasons for this can be following:

- A lack of a corporate and innovation strategy as a basis for decision-making process.
- Insufficiency of information as a basis for decision-making process.

It also happens that instead of facts, the management's own beliefs dominate, and decisions are made from within, which later turn out to be false.

b) Slow structures

It usually happens like this: the larger is a company, the slower are internal organizational processes. Low speed processes with a long decision-making process can become like a death sentence for the whole innovation process. Moreover, there are often communication and interface issues. It is obvious

that all of these factors negatively affect the quality and efficiency of the Research and Development process.

It is very opportunely to mention a couple of advantages of start-ups over large corporations;

- They are less complex, quick and more agile due to their size, absence of numerous hierarchies, bureaucracies.
- They are better networked and interlocked. This positively affects processes acceleration, collaboration and sometimes even openness and willingness to change.

c) Lack of market orientation

One more important reason of project failures is low level of market and customer orientation. Often products do not provide rather convincing customer value, or it is not enough different from similar existing products.

It can be caused by:

- Too much focus on technological process.
- Lack of time for customer analysis and product specifications development (Apple customers used to new iPhone every year)
- Low level of accessibility to customers and customer information because of weak Sales departments or due to tensions between Sales and Technology departments.
- A lot of companies are sure that they already know their target group and existing customers, relying on own assumptions and missing latent and actual needs.

All of this is not a good way to develop innovative unique products. The more information you have about your target group, the more chances you have in your innovative project. So,

I believe that investing in extensive customer research and needs research is a key success factor for R&D.

d) I would also add here a couple of causes which at least in theory lead to project failures such as violation of work time limits; getting results that don't meet the requirements (the product is not patentable or it does not correspond to the market demand); it is impossible to transfer the results of laboratory tests to the existing technical or technological level.

I will express already obvious state of affairs: companies spend a great money on innovations and suffer because of enormous financial losses. That means that a sector of Research and Development has a lot of space to grow. Further in this chapter I would like to analyze other risks threatening the process of Research and Development and leading numerous innovative projects to failure.

2.2 Key external threats

During case studies, I have already deeply analyzed the most superficial risk of innovation process - financial losses due to project failure. Then I have also provided a number of *internal reasons* compromising project's successfulness. Further I am going to mention more profound external threats. Talking about risks and possible losses, enterprises which carry out Research and Development work interact with the external environment, so external factors have a significant impact on both the process of R&D and the activities of the enterprise as a whole. In the external environment, we can distinguish indirect factors (political, economic, scientific and technical, social,

environmental, legal features), as well as direct factors (competitors, consumers, investors, suppliers).

Among external indirect factors of conducting Research and Development processes, *economic risks* should be mentioned first of all. Such risks imply inflationary processes, instability of exchange rates, slowing investment activity due to economic sanctions etc. In Russia political regulations are aimed at activating innovation processes and maximizing the contribution to the development of research (as an evidence - the steady growth of budget funding for scientific research from 140.5 billion rubles in 2005 to 617.3 billion rubles in 2015).

There are also *social threats* which imply high unemployment rate, low living standards, low real income of the population and low level of purchasing capacity.

Last of eternal indirect factors I would mention force *majeures and ecological threats* which imply inconsistency of ongoing work and new developments and requirements of environmental legislation.

Considering external direct factors affecting Research and Development process they include:

- Factors causing *threats of competition*: high indicators of competitors' scientific and technical developments, low cost of competitors' R&D processes, high speed of competitors' R&D processes, huge competitors' reputation in the sector of innovations. The existence of a large number of competitors not only encourages overall growth, but also creates obstacles for R&D. Here the main risk is the possibility of development a product or technology by competitors with a lower price and

with a better customer satisfaction, using unfair techniques and obtaining results of innovative developments of other companies.

- *Investors* can also be seen as external direct threat. Corporations often experience difficulties with attracting investments during the initial stages of the Research and Development, which may lead to a lack of funds at the initial stages and the closure of the project. In addition, investors may interfere excessively in the work of the research Department and require access to confidential information, which carries the risk of information leakage and negatively affects the development process.

- I would also mention *interaction with consumers* whose needs are never stable and *interaction with suppliers* as two more external direct factors. Since certain delays in the supply of raw materials and materials necessary for conducting R&D processes slow down the entire innovation process of the enterprise. In addition, materials received from suppliers may not meet the standards and may have a higher cost than is stipulated in the preliminary estimates for the R & d process.

2.3 Research and development organizational structure types

So, I have described a number of key threats for R&D and innovations. In order to avoid internal organizational risks, the company has to choose an appropriate organizational type in regards to the process of Research and Development. That is why now I am going to consider several different types of the structure of R&D and analyze their own positive and negative features.

Today organizational structure of Research and Development departments is rather diverse. Usually big corporations choose between five organizational R&D structure types. Obviously, every type has its own advantages and drawbacks. The issue is a selection and a use of criteria for the organizational structure of R&D services within enterprises. An inappropriate strategy choice usually leads to such issue. That is why a process of strategy selection requires, as I have already mentioned, consideration a number of specific conditions regarding capital accumulation and competition.

Specialists manage to distinguish the following five types of organizational structures which are organized by:

- Scientific branches (fields of knowledge) and technology-functional structure
- Product / technology attributes (thematic structure type)
- Projects (project-based)
- Organized according to the stages of Research and Development process (phased)
- Mixed (or combined) structures (system-component)

1. At the technology-functional structure, Research and Development departments are usually divided into numerous sectors. Each of them is dealing with a certain separate branch of science (usually quite narrow one).

One of the most important advantages of the first organizational structure type is an opportunity of creation a number of coordinated groups of high-quality specialists in one such sector. There usually is a creative atmosphere, without any parallelism within a project.

The main drawback of this structure type is a significant isolation of certain areas of Research and development caused by the functional form of management organization. That leads to an organizational gap between research departments, laboratories, on the one hand, and production, sales services and market research, on the other hand. With such a significant organizational autonomy, it is rather difficult to achieve close cooperation between different departments' specialists. Moreover, the processes of monitoring, planning and operational regulation of the process of implementing research and project programs become even more complicated. That is why it is necessary always keep in mind a perfectly coordinated work at the horizontal level. The thing is that such divisions are built on a functional principle, so most of employees become narrow specialists and sometimes they are unable to resolve issues which exists beyond the traditional scope of their narrow specialization.

2. The second type of organizational structure is based on product or technological characteristics (that is why it is also called as thematic structure type). According to the abovementioned organizational structure, workers of Research and Development departments have to be primarily focused on the final result instead of the problems and requirements of production and sales. There are two big advantages of this organizational structure type which a) raises the probability of fundamentally new ideas appearance, as well as the opportunity to combine the stages of development by organizing their implementation in a parallel-sequential scheme. Here I can also mention an opportunity to unify the design and technical

solutions within the framework of a certain task; b) moreover, it allows to increase a level of personal responsibility of creative specialists and project management aiming at high-quality performance in accordance to the current theme and product.

Obviously, this structure type also has its disadvantages. First of all, an attention to this area of development is higher. This creates a threat of underestimation of long-term and functional research. Also, a number of difficulties in improvement the skills of personnel arise; an uneven load of laboratory equipment and experimental facilities occurs from time to time; and the intensity of the resource usage is becoming relatively low due to inability of a narrow specialists to work at full steam in regards to wide range of problems.

I have studied this organizational structure type taking as an example GE company (or General Electric). There is an organizational structure of an R&D division which is purely based on a product line at the innovation project of radio relay systems development.

3. The next structure type is primarily based on project. Such organization type is usually used in companies where the simultaneous implementation of several projects is a main goal. This structure type is rather flexible even taking into account the fact that it requires the involvement of specialists in a numerous branch of science. However, it is always necessary to determine the number of research fields and researchers of certain specialties and combine them into groups at the initial stages of a new Research and Development project organized by such structure. This organizational structure is also applicable for organizations where a new product is predominantly created and

developed at every stage of the innovation process. It is especially efficient at the last stages of the process of a new product development. The type of project structure also makes it easier to plan, to control, and to evaluate the project based on both scientific and commercial criteria.

The project work organization is characterized by high efficiency indicators and high speed of developments implementation. It happens this way because the divisions are totally responsible for the current product implementation in production.

I have found just the only drawback of this organizational structure type. There is a common issue: a lack of time for scientists for conducting basic researches, studying and solving promising problems, according to a number of American experts' surveys.

4. Phased structure implies a form of labor division, where every department whether is it responsible for theoretical or exploratory research, engineering and technological development, design, creation of prototypes is separated from each other. It is called phased due to the structure organized by stages of Research and Development process.

This type of organizational structure is also aimed at helping scientists to conduct scientific work, while the whole engineering staff is fully devoted to the work in accordance with their specialization.

In my humble opinion, the biggest drawback of this structure type is rather obvious - the lack of flexibility. It can be especially seen in companies where products are changed frequently. This structure is also applicable in industries and

organizations where the same products are being produced for a long time.

5. One more type of organizational structure is called mixed structure (or combinational /system-component). From the practical perspective, it is the most frequently used organizational structure type among big corporations and companies paying special attention to innovations and to the process of Research and Development. It creates the best opportunity for high-quality and fast-growing performance of the entire range of Research and Development departments' activity.

A *matrix structure* is usually included into mixed structures. They imply a combination of functional and product (thematic) features. Obviously, flexibility is the main advantage of a matrix organizational structure type. At this structure an employee should be able to perform two functions simultaneously, for example: being a project Manager while performing a significant amount of work within this project.

It is rather important that the matrix organizational structure can be applicable to any stage of a new project development cycle with an option to move from one type of work to another (such as idea planning and financing, sample development, experimental work, etc.)

There are two different types of matrix structure: *a) design-matrix* and *b) functional-matrix*.

At the organizations who chose a usage of *design-matrix* structure, employees who represent functional divisions are usually accountable directly to the project Manager during the entire time of project's creation, development and implementation.

Within design-matrix structure, the Project Manager has a following responsibilities: task distribution among employees, their activity control and coordination, management of the overall work process related to the innovative project. In his turn, from the perspective of the head of any functional division it is necessary to provide his employees with all the necessary assistance, to distribute specialists in their areas of work, etc.

The design matrix structure is used at companies where an organization performs a few number of projects which are different from each other. Aerospace, pharmaceutical, chemical and, of course *electronic/ software* are industries where the design matrix type is most widely used. In order to provide a couple of examples of design matrix forms of Research and Development management within IT industry, I would choose its introducing at *"IBM"* and *"GE"* ("General electric"). And as examples out of IT sphere – famous US "American Cyanamid" and "Texas Instruments".

Taking into account the second type - *functional matrix* structure, here specialists working on the project are not completely accountable to the project Manager, but all of them work under a dual subordination. The head of an innovation project, Project Manager, performs the duties of a qualified leader of the creative direction of the project. In their turn, every head of functional department provides the organization of implementation of solutions in accordance with the common current reporting requirements. This structure is perfectly applicable to companies where there is just a couple of complicated long-term R&D projects and a bigger number of streaming ones.

Therefore, in order to name one of most suitable structure for the specific innovative projects' development, I would choose the matrix form. Firstly, it creates a perfect opportunity for simultaneous work of various types at different stages of projects' development. Secondly, there is an ability for corporation to adapt for the changing conditions within the whole organization.

It is rather obvious, but still worth to be mentioned, that Research and Development organizational structures are not permanent. There is a number of impartial circumstances that bring it in line with new tasks, changes and improvements in the economic entity or even those which make it necessary to revise the whole innovation structure. The main such factors stimulating changes within Research and Development organizational structures are:

- Changes in the Research and Development technology in connection with the current expansion of the computers' usage as well as latest scientific and technological progress;
- Subject areas' changes in regards to ongoing projects of Research and Development;
- Significant changes at the core organization's objectives or even its entire strategy;
- A decrease or instability at the R&D efficiency indicators, innovative centers' and laboratories' indicators caused by the discrepancy within their organizational structure (or by of performing same functions by different departments), as a result – a great amount of wasted time and the inertia of the whole system;

- Thematic or product changes within the structure of the plan which lead to the changes in specialists' number.

Moreover, the organizational structures of R&D management should be reviewed from time to time in order to change the formal and informal relationships that have already been developed along the line of command, in order to eliminate the inertia and conservatism of the system as a whole.

In cases where organizational management structures manage to create an opportunity both for efficient use of resources, and provide an active systematic search for further innovative development of production with the background of the latest scientific achievements, these structures are maximally effective. Most specialists who are analyzing the R&D organizational structure theory sector are sure that such organizational structure should be primarily determined in accordance with the innovation strategy. Corporations must be flexible if they have chosen the implementation of a leadership strategy. Such high level of flexibility can be achieved by the staff placement structure. It creates an opportunity for new activities' adaption, while at the same time, the structure should be based on the free transfer of information principle (both horizontally and vertically). It leads to a higher level of employees' participation in decision-making process, which raises the whole R&D process evaluation.

Organizations which state an increase of efficiency and stability as a primary objective by creating so-called mechanistic structures frequently use a so-called «follow the leader» strategy. Such mechanistic structures usually have quite high level of responsibilities formalization and low level of Junior

management participation in decision-making process. Also, there are rigid vertical relations. Adaptability of the organization to new conditions is not a goal of mechanistic structures instead of managerial control. In case an organization is aimed at combination of the features both of organic and mechanistic structures, it should choose the strategy of simulation.

Nevertheless, today rather different structural approach to Research and Development is being created. I mean the so-called «limitless» organization principle proposed by Jack Welch who is the CEO of «General Electric» company. Both vertical and horizontal boundaries are eliminated according to this principle. As a result, external barriers between the company, its suppliers and customers are broken. This implies a break of the orders chain from the main center and introduction of a system where there is no inter control among managers. Moreover, temporary creative groups replace previous individual hardware instances. The evaluation of the group work is primarily based on employees' and managers' participation in decision-making process. There is a training organization, whose concept is adopted by great number of corporations acting in the field of Research & Development and innovation (especially by large software and electronic corporations). And such organization with no limits is rather close to its ideal.

Such training organization has 5 central features:

- employees are free from old ways of thinking;
- employees learn to be open about each other;
- employees understand how the organization really works;

- employees identify approved work plans and perspectives;
- employees work together to implement these perspectives;

In order to boost the improvement of the entire production system, they involve project managers and employees representing each level of the creative activity sphere.

In a brief conclusion of the second chapter, I would like to stress that every medium and small company representing the IT sector faces a great number of difficulties during the process of R&D and innovations. At a first glance, it seems like large corporations which are also IT market leaders do not have a lot of obstacles and their innovative projects should have rather higher success rate of such projects. However, I have analyzed the corresponding data and statistics concerning success rate of such corporations and gave a number of famous examples considering failed projects of companies like Apple, Amazon or Samsung. After showing a low success rate and numerous proofs that there is a lot of space to grow for R&D, in the last third chapter I am going to propose a couple of recommendations in order to increase effectiveness of Research and Development both internally and externally.

CHAPTER 3 How to increase effectiveness of R&D and innovations?

3.1 R&D evaluation system

First of all, in order to increase the existing level of R&D effectiveness, companies have to evaluate corresponding indicators precisely. For the better understanding of these indicators, it would be helpful to analyze key effects arising from R&D implementation. Economic efficiency implies the correlation of the result with the costs associated with its achievement, this is a relative value. Different indicators are used here. But there are also effects, that is, results, they can also be different: technical, economic, and other. Economic effects are always measured in absolute terms. During planning and evaluating implemented Research and Development project, it is necessary to evaluate both effectiveness and efficiency in a complex. After that it is possible to evaluate the overall assessment of the Research and Development effectiveness.

So, there are three main groups of effects which arise from the implementation of innovative projects:

a) Technical effects

Each innovation project should have its own specific measures of technical effects. During the process of project implementation, the specified characteristics can be developed (such as hardness, strength, heat resistance or wear resistance of the material, etc.). Considering the sector of Information Technology, direct technical effects for microprocessor technology can be measured by performance and memory capacity parameters. An objective assessment of direct technical

effects can only be obtained with the participation of researchers and engineers who should have an access to the data banks for the relevant fields of science and technology in order to have a base for comparing the results achieved and available known results. Along with direct effects, there may be indirect technical effects. Even if the innovation did not achieve the planned technical effect, there are training effects in the area of new technologies, their methods and tools improvement. In addition, it is also possible to patent a technical know-how and fix priorities, as well as identify weaknesses in the equipment and technology of the enterprise. Often unsuccessful innovations in commercial terms give rise to subsequent processes of innovation, which are much more effective due to the creation of an «innovation climate».

b) Economic effects

Such effects, as well as technical ones, can be decomposed into direct and indirect ones. Direct effects imply profit estimation, margin profit, cost reduction, etc. Innovations that affect the entire production process are difficult to measure in terms of profit growth or cost reduction. Rationalization of the production process can be manifested in reducing the volume of waste, reducing the time of the production process, improving product quality, increasing flexibility and stability, as well as reduction of the harmful impact on the environment. Indirect economic effects relate to the field of competition: a decrease in sales from competitors; the increase in the cost of the competition, providing innovative leadership of the enterprise. Effects of this type can only rarely be quantified.

c) Other effects

They are located in the system or individual area. Talking about individual aspects of measuring the success of R&D developers, it is important for the developers to recognize their contribution in publications, receiving prestigious awards, etc. Today, one of the most indisputable indicators of the success of innovations in the field of products and technologies is the so-called environmental effect – the reduction of effects which are harmful for the environment. The future belongs to energy-saving, waste-free and environmentally friendly technologies.

There are also humanities and social results of implementing innovations that which also relate to other effects:

- the creation of new workplaces;
- an improvement of working conditions;
- the creation of humanistic relations within the team by introducing new methods of control;
- an acceleration of passing of the project and better control over the phases of its execution;
- a growth in management transparency of costs and results;
- a higher level of an enterprise flexibility and its speed of reaction in regards to adapting to changing external conditions.

It is usually difficult to quantify achievements of the internal management effects. So that, they are usually seen in a form of «chances» and «strengths» of the enterprise that ensure strategic success. Different methods can be used to at evaluation the economic effects (economic performance of R&D). First of all, they rely on the calculation and comparison of costs for alternative R&D options. The essence of the method implies

calculation and comparison of the total costs of alternative options. An alternative that requires less current and capital costs is preferable. The resulting revenue is not considered in this method. Therefore, the method of calculating and comparing costs can be also used in such cases where the result of projects will not be sold, but will be used for the company's own needs. If the development is aimed only at commercial purposes, then financial and economic criteria such as revenue, profit, and sales should be considered as the main indicators for the assessment of future economic success, as well as efficiency evaluation (for example, profitability).

Research and Development projects which are being conducted at the expense of state programs, patronage and sponsorship is most often evaluated by social, political, environmental and other similar criteria. In some cases, in particular, to attract state or municipal funding, an assessment of the national and economic effectiveness of the project can be carried out. For instance, meeting the demand for particularly important goods; social and environmental factors: employment, environmental cleanliness; ensuring security and prestige of the state. In other words, the result of R & d is linked to the consequences of its implementation, but not necessarily to commercial benefits.

3.2 Cost-efficiency drivers

In the previous chapter I have analyzed main risks and threats of Research and Development process which lead to projects ineffectiveness or even complete failure. All of these factors can be divided into two big clusters: internal influence

factors and eternal influence factors. In its turn, the proposed recommendations, which should increase success rate and improve Research and Development projects' effectiveness will be also divided into two types: *1) Cost-efficiency drivers* and *2) Productivity boosting drivers*.

Cost-efficiency factors primarily relate to the cost and labor reduction tools, time-saving instruments and so on, while productivity drivers imply project management and organizational structure improvement. I would like to start with cost-efficiency instruments because they are more explicit and their causal relationship is much more evident and apparent instead of tools aimed at productivity increase.

First type of drivers includes 4 instruments: a) the reduction of material costs, b) the reduction of labor costs, c) the saving of capital investments and d) time-saving instruments.

a) Material costs reduction is one of key measures for a significant increase of the growth of sales and for an increase in production rates. The significant reduction and following advanced results can be achieved by a number of aspects such as:

- the usage of new equipment, recent technologies and technological processes;
- reduction of the cost of project diagnostics, monitoring its effectiveness and other processes of its inspection;
- increased working life of equipment;
- usage of import-substituting materials and replacement of materials used in production with cheap ones where it is possible;

b) Labor costs reduction implies automatization of technological processes of Research and Development and a maximal reduction of processes requiring pure human labor force.

- the usage of modern equipment substituting human labor and automatization of Research and Development processes;
- reduction of occupational diseases and professional injuries sustained during the innovation process;
- improvement of standards and regulations, incentive system for employees' remuneration;
- peak personnel development;

c) In the previous chapter I have already mentioned that frequently large corporations experience problems with slow organizational structures. The only way to overcome such problem is a usage of time-saving instrument which include:

- increase the level of production intensification by production processes automatization;
- reduction of the time during non-technological breaks and downtime during the transition from one stage of the production process to another;
- reduction the time to get control information;

d) Capital investment saving is one more important aspect which implies:

- increase of the working life cycle of machinery, equipment, and vehicles
- improvement of technical, technological and organizational aspects in the capital structures and objects construction;

The combination of the abovementioned tools and instruments is quite helpful at economic indicators' increase in regards to the reduction of production and Research and Development processes costs. It should also reduce costs related to money spent on materials needed for R&D, pure human labor which is going to be reduced and automized, reduction of wasted and gaped time and money invested in corporation's capital.

3.3 Productivity boosting drivers

It is indisputable, the improvement of economic aspects of the Research and Development process is vitally important for every organization. However, I believe that in order to boost productivity indicators and achieve really groundbreaking effect of the innovation development, it is essential to change internal project management, its organizational structure and permanently analyze why the product became successful or abortive one.

That is why now I am going to focus on the second cluster of drivers which are aimed at productivity boost**.** It is worth to be mentioned that this type of instruments is primarily aimed at the internal project management improvement. These factors do not affect economic indicators in a direct way, so I would say they are less apparent and less superficial. However, the result of their usage may be much more stunning and groundbreaking. Such drivers type includes following instruments and ways of improvement: a) the analysis and improvement of previous failed projects; b) risks reduction; c) the internal project management; d) strategies and methods of projects' commercialization; e) state-level factors making product successful.

a) In case a company has already experienced innovation projects' launching, first of all it should conduct the analysis of the previous project's research, production, implementation and commercialization stages. Most often problems or even a complete failure of any innovation project is caused by just one backward stage. Obviously, every of such underdeveloped parts have to be improved in order to make the next project in a smoother way. Surprisingly, the statistics shows that the most troublesome stage is the final one – a process of a project commercialization. I will focus on this stage more in details later in this chapter during the point b.

b) During the process of innovative project selection, it is always necessary to pay attention to ways aimed at the whole project's risks reduction.

There is a number of different techniques aimed at risks reduction in R&D. I would like to focus on the following three ones:

1) to split risks among every project participant (in other words, to transfer a part of the risk to collaborators and so-called co-executors);

2) risk insurance;

3) to cover unpredictable expenses by the preliminarily funds reserving;

- The process of risk distribution going on during an innovation project financial plan and other contract documentation development. In order to expand or to make the potential investors range narrower, R&D project participants make a number of risk-reducing decisions. The participants have

to show as much flexibility during the process of appropriate negotiations as much of the risk they are willing to accept.

Above I have already provided a data showing a critically high number of R&D projects that had a delay in its implementation (including even large corporations). Obviously, such delays lead to a significant expenditure growth in regards to cost of labor, raw materials and so on, exceeding the initially expected cost of the whole Research and Development project. That is why companies pay also so much of attention to the process of risk insurance, which is the next risk-reducing instrument.

- The instrument which is called risk insurance implies a certain threatening part transmitted to a special insurance company. The process of risk reduction by the risk insurance tool is an integral essential part of every Research and Development project. An organization which carries out an innovative project has an opportunity to minimize almost all property risks, as well as numerous commercial, credit and industrial risks thanks to insurance companies. However, this method as its own drawbacks and limitations. One of the most superficial ones is that insurance is usually does not relate to risks associated with the partners' bad faith, which happens quite often.

- Moreover, in case the probability of a risk occurrence event is very high, such risks cannot be covered by insurance because of non-acceptance by an insurance company;
- The contribution amount is always established by the side of insurance company. That is why in most cases the sum of money is obscenely high while the process of entering into the insurance contract;

- The certain amount of reserved funds provides an opportunity to establish a coherent balance between the level of potential risks which affects the cost of the Research and Development project and between the cost which is necessary in case of different kind of failures during the implementation process of the whole innovative project. It is also worth to be mentioned that this takes into account the accuracy of the initial assessment of the general cost of the innovation project and all its elements.

Most of the mentioned above tools and techniques are aimed at trade secret protection which is one of the most important part in regards to innovation process' risk reduction from the developer's perspective.

Usually, the level of research and Development project manager's experience and the capabilities of the innovation organization. primarily affect the choice of a certain way aimed at risk minimization. However, in order to achieve a more effective result at risk minimization during all stages of the project implementation, a set of instruments is used.

c) In my humble opinion, the process of innovative project's management is the most important aspect in Research and Development. It includes all the main stages such as early research process, the product development process and the process of product commercialization on the certain market. The management process begins almost from the moment of the idea generation or the creation of an intellectual R&D product. From that moment it is necessary to pass through quite a long way of product development, its design, a protection of intellectual property, feasible analysis of the previous success/ failed

innovation project, business planning, search for financial, material and human resources and so on. Let us not forget about project funding: a search for an appropriate investor with rational requirements and cooperation contract conclusion. Next, the project management has to ensure that every stage of marketing process (pre-production, production and sales of products, the organization of a network of sales and service organizations, the organization of financial flow control, social process management, risk management, and much more) are going smoothly. One of the most obvious managerial difficulties at this step is that the innovation project time interval is usually limited to a year after the investment payback period, while the duration of the innovation life cycle is significantly longer.

After the enumeration of such complex and various work types required during the whole process of the innovation projects' implementation it became rather obvious that there is also a number of high requirements for the innovation managers qualification. First of all, they must have the body of knowledge and skills in the field of attraction the necessary additional resources as well as optimization the all available ones in order to implement the Research and Development project during its every stage in a most successful way.

Such multitasking employees should have a systemic knowledge as well as comprehensive knowledge about the project (in this case, a project is kind of a such system). In my humble opinion, the innovation project manager or the manager of Research and Development perhaps is the highest qualification of a management in General. None of any other specialization in management requires such a voluminous

knowledge and practical skills. Moreover, an innovation manager has to be proficient at traditional Economics knowledge, as well as at every functional section of management. He must also have the basic knowledge at technics and engineering in regards to the industry where innovation is produced, as well as to have knowledge of the patenting and protection of intellectual property basics, and, of course he has to know key principles of intellectual property commercialization. It may be seemed like an innovation project manager is the person responsible for the whole Research and Development process starting from the idea generation stage finishing project's commercialization. This is not true at all, however, innovation project manager is kind of link connecting all of the R&D departments' specialists, that is why this person must know and consider all the nuances in regards to each specialist of each department. Moreover, this position relates to numerous potential risks and threats, so that there is an entire project management team instead of a single one.

At this point I would like to mention two concepts or two methods of business process management: the first one is engineering, the second one - reengineering.

- Engineering process implies an improvement, optimization and rationalization of a process (by the usage of improving innovations). Usually, engineering helps to increase economic effectiveness indicators of performance insignificantly (10% - 50%)

- The process of reengineering can be seen as the use of radical innovations leading to an increase in the economic efficiency indicators much more effectively: by tens or hundreds

of percent. From the perspective of the innovation project manager, he should consider and use both of these methods in his work: the strategy of actions is based on reengineering, while the tactics of everyday activities is mostly related to the engineering process.

Regarding the entire project of Research and Development it can be seen as a division into three major stages: 1) project development 2) production 3) project commercialization. Each stage of the innovation process has its own management specifics. Let me analyze each them one by one.

- The first stage of project's design includes idea generation and research analytical work. The final result of this stage is a set of working design documentation, including graphic and text parts. In addition, one of the central appendices to such documentation is the prototype and its test report, which is usually agreed with the innovation project customer or with a special supervision service representative (they exist in sectors such as health or energy).

Management at the first part, the project development stage, requires the project manager to be proficient in the field of an appropriate science as well as being able to manage modern research methods, to know the basics of the main regulatory documents and standards used at the product design, the infrastructure for monitoring, supervision and approval of documentation. Moreover, the head manager of the projects must provide timely assistance and other help to developers in preparing applications for intellectual property objects.

During the first period the head project manager has a special responsibility requiring first marketing efforts in regards

to the future production. I mean he has to consider volumes of products he is able potentially agree with consumers in the future, also take into account the volumes of purchased raw materials, Research and Development process components, necessary equipment, etc. At this stage a number of issues related to consumers arise. For example, there is a need to persuade consumers almost without precise product data (since the products sold in the future may be rather different from the current ones, and the advertising campaign of the product is still practically absent). This is why even the first stage of marketing is associated with a particularly large risk factor. In order to reduce such factors, the organization usually tries to interacts with the consumer organization, forming a kind of elementary cluster. This is a case close to mentioned in the previous chapter, where I have described how it is possible to reduce the risk of supplies of raw materials which are necessary for the production process by forming clusters with supplier organizations.

I still did not pay too much attention to the personnel management. In its turn, the whole staff usually consists primarily of highly qualified employees, and often outstanding individuals, scientists, their management methods should be rather unusual. So that the construction of the organizational structure should be close to adhocratic system. In other words, at such system professional qualities, knowledge, and qualifications always come first.

2) The second stage is a management of production process. It begins with the preparation of technologies necessary during the production process and is finished by the preparation of products for the commercial sales.

Technological preparation of production can be compared to the preparation of an army for a decisive battle – during this critically important stage the state of all future production is specified and determined. During this period each process, equipment, costs of labor force, a plan of communication, innovation product quality control, delivery plan and sales plan are determined by the technological process of production. They initially launch a test batch of products in order to check technological process. Then it is necessary to adjust both the technological process and the working design documentation and to start the production process of the innovation product.

Production process management also has a couple of its own specific features such as:

- the Manager must know the technological process in operational terms (every workplace, possess basic production skills etc.);
- the whole production process must be controlled by the head of project management team. He has to plan and ensure the logistics of each workplace, to provide sustainable communication links between departments and innovation specialists;
- a high level of motivation maintenance in order to increase economic productivity indicators is one more permanent responsibility of the project manager.

3) I have already mentioned that however strange, the last stage which implies the commercialization process is the most problematic and troublesome one. It usually includes not only the process of distribution and sales of products, but also a process of commercial transaction for the purpose to sale intellectual

property rights. From the perspective of marketing, during this stage a real campaign begins. First of all, a wide advertising campaign must be organized because the product is not known to the market and its consumers. At the initial stages, the cost of such campaign may include a significant share of the money invested in the project; then it should be a certain part of organization's income gained from the sale of the innovation product. In both cases a marketing campaign requires a high-qualified marketing specialist who has advertising skills and who is able to enter into long-term contracts for the new innovation product.

There is a number of activities related to sales at this stage. I mean product packaging, its transportation, negotiation regarding price aspects, storage, and research and inventory management. An optimization of the product volumes considering storage (such as sudden company demands, unforeseen production stops, raw materials shipment interruptions) determines the inventory management aspects. Last but not least, product inventory process should not cause any losses to the organization. Quality of packaging, product appearance, the entire product attractiveness and its design are imposed be numerous special requirements at the nowadays market in regards to the clients' consumption and innovation product reliability during transportation. Considering packaging, today it can be seen as a "small innovation product advertisement". Usually it contains an innovation product image, its general and specific characteristics, the detail of manufacturer, and its trademark altogether. As a rule, modern

large manufacturing enterprises have their own services and shops.

Concerning the process of intellectual products commercialization there is a number of factors affecting its entire effectiveness. The situation in Information Technology sector all over the world and, in particular, Russia, with a R&D projects commercialization is quite poor today: there is a scarcity of specialists in the field of patent activities as well as the lack of specialized consulting firms. Also, banking and legislation systems have to be imperfected significantly. Patent licenses is one of the most profitable types of innovation process commercialization abroad. There is also a need of a steady mechanism being created in order to transfer money within a country. However, this way is not the only way the diffusion of innovation acceleration.

Moreover, a state is also a beneficiary party of the process of intellectual property rights commercialization, but not only manufacturing organizations. For example, in Russia after a thorough adjustment of patent law (in the Civil code of the Russian Federation, part 4) a significant market expansion is expected. In particular, after fees being cancelled (or to be more precise, replaced by deferred benefits), the income from the sale of intellectual property rights or from the amount of investment in an innovative project will not only cover all the organization losses from the absence of fees, but will also bring huge benefits to all participants in the “patent process”. I mean the state itself first of all. However, issues here are quite specific, there is also a number of rather high requirements in regards to a project manager qualification within the field of innovation property

commercialization and its implementation. In this regard, it is necessary, in my opinion, to change the standard of training in innovative management significantly.

d) That is quite surprising, however, creating an innovation is not the end of R&D project implementation. I would even say it is only half of the job. The most important and troublesome part of the whole innovation project cycle is entering the market. Far not all of R&D products have succeeded at this stage of the innovation process. I can take Russian Research and Development industry as an example: it is necessary to solve many problems and avoid a number of pitfalls. Some of them are related to the evaluation of innovative projects, while others are related to the infrastructure for innovation development that is not yet developed. How do innovations enter the economy, and what stages do they go through? What are the conditions or prerequisites for successful implementation of innovations? What opportunities do innovators have and what do they need? Let's trace the process of commercialization of innovation from the point of view of all participants of a project, because the success of an innovation primarily depends on their effective interaction between each other. Every participant sets objectives of the project taking into account their own interests foremost whether they are representatives of investment institutions or some business community, whether they are private investors, other inventors and innovators or even the state. Considering business community, it primarily hopes to get new market segments or market niches in order to implement the new product after Research and Development process (or new technologies in order to produce already existing products for the purpose of

their competitiveness growth and consistent win of the market). From the perspective of investment institutions or private investors, first of all, they expect to gain new objects of high-yielding promising investment. Investments provide the state with economic independence as well as accelerates development of industry and the whole national economy. Finally, other inventors or innovators, they are looking for the provision of themselves with the means of further research, develop businesses, or compensate for the resources and labor costs invested. In addition, innovative consumers are no less important than manufacturers. To the question “Do you need a regular toothpaste or innovative?” or “Do you need a conventional metal coating or innovative, nanotechnological one?”, most of them will respond: “Of course, new, innovative ones!” For interaction between participants to take place, the innovator must attract the attention of potential partners to their innovation and convince them that a new product or invented technology will be implemented on the market. During the ideas generating process and a process of running a business, within the Research and Development team — those members who work on the purpose of commercialization - the close collective interaction is essential. However, usually, there is a number of people who are behind radical innovations, and sometimes the fate of every generated idea depends on them. Sometimes it is quite difficult to create a commercialization strategy for the ideas, created R&D products and technologies, but is necessary to develop own unique commercialization strategy for every innovation project on the basis of existing opportunities for the idea implementation into the market. The choice of the commercialization method is

the main point in the strategy development process. First, the innovator must determine their role in this process and make a specific decision — to continue research to create a series of improving innovations, move to another area of research, or participate in the process of bringing the invention to the market, or perhaps sell the technology and leave this area of activity. It is very important to be able to protect intellectual property rights. This can be done through various mechanisms — patent protection, trademark registration, and the introduction of a trade secret regime. A competent solution of this issue will expand the innovator's further opportunities and position in the business community as well as upcoming real transactions. Then it is necessary to choose the appropriate commercialization strategy. Of course, every innovation is unique and individual, so that the ways of product commercialization can be varied. Let me describe the three such methods and various ways of their implementation:

- Independent usage of development for business organization is the most common form of realizing the potential of innovation. It usually involves organization of production and sale of finished products, production and leasing of equipment, provision of engineering services.
- The next way is a partial assignment of intellectual property rights. This method includes: licenses sale and franchising; contract for joint development of finished products with the consumer in the joint registration of intellectual property rights; transfer of production secrets (by own employees’ provision).

- One more way to commercialize innovation product is an intellectual rights transition to the third party which can be realized through the sale of patent rights , through the contract on alienation of exclusive rights or through the obtaining a contract for further research and development with the condition that the rights to patent the received RIDS will pass to the customer. For large-scale market penetration, the first two methods do not exclude each other in case of market definition from a geographical point of view. A company or individual — the current copyright holder — can use its own developments in the territory where the innovation was created and simultaneously sell its licenses to carry out similar activities in other territories. It is worth to be mentioned, that such situations are rather frequent in practice nowadays. First of all, the process of product commercialization involves conducting comparative financial calculations in order to assess the profitability level of a particular method of commercialization in a particular market.

e) There is always a number of factors making any R&D project more successful. Here I am going to mention powerful *state-level factors* which are able to boost productivity indicators.

- State Order

The first state-level factor of innovation success is the demand for new technologies and products. The state order for innovation is an incentive for innovative activities of universities, research institutes and companies. For example, such essential elements of smartphones as GPS, touch screens or Internet access were originally developed by the United States Department of State Defense, while solar panels and Tesla

battery technology — with the support of the US Department of Energy (DOE).

An example of such innovation in Russia is the GLONASS navigation system, which was originally created for military purposes by state order. In 1995 it became available for civilian use and is currently used in navigation devices, radar detectors and other systems.

- Financing

The state selectively sponsors basic and applied research in priority areas or research with potential. In other words, I am talking not only about national security and defense issues, but also about research beyond these topics. In Russia, the state has played a major role in shaping the innovation Finance system, including the venture capital market.

In the future, it will be necessary to change the attitude to investment in innovations and increase risk tolerance, because only a small part of innovative projects end in grandiose success. Reducing the level of bureaucracy when issuing grants can simplify the process of attracting funding for innovation development.

- Infrastructure

I would like to considering the next state-level driver, which is infrastructure, taking the example of Russia. There are four types of innovation development institutions successfully operating in Russia:

- funding for basic or applied research;
- direct financing of innovative companies (“VEB Innovations”);

- techno parks, incubators and other institutions that provide services to innovative companies (“SKOLKOVO”, “Mosgormash”);
- funding for certain priority areas - Internet initiative development Fund (FII).

In Russia the infrastructure for the innovation development was created, but there has not yet been a qualitative leap in their development and business activity.

- The culture of innovation

The state also plays a significant role in a cultural development of entrepreneurship and innovation by implementing educational programs, supporting mentoring systems, creating and assisting development agencies/ institutions. It also encourages national innovative entrepreneurship.

In my opinion, Russia has come a long way in developing an entrepreneurial culture. However, taking into account the relatively short history of the market economy in the country, it is necessary to continue the course of promoting entrepreneurship and innovation.

As a brief conclusion of the third chapter I would stress in spite of risks and threats of the innovation process, which were divided into internal and external factors, my above mentioned recommendations, which are theoretically aimed at improvement of Research and Development projects’ effectiveness as well as at the increase of the success rate, were divided into Cost-efficiency drivers and drivers boosting productivity. Cost-efficiency drivers are related to the cost and labor reduction tools, time-saving instruments and so on and

implied tools aimed at the reduction of material costs, the reduction of labor costs, the saving of capital investments and time-saving instruments. The second type of drivers is rather less explicit: it implies project management and organizational structure improvement tools such as the analysis and improvement of previous failed projects, risks reduction, the internal innovation project management, strategies and methods of projects' commercialization and state-level factors making product successful. Also, I have analyzed an innovation project manager position, its required skills and knowledge fields. However, every innovative company, which conducts Research and Development processes, has to combine both cost-efficiency instruments with the productivity-boosting ones in order to avoid numerous failed innovation projects and in order to increase the entire projects' success rate.

CONCLUSION

In conclusion of the paper as a whole, I would like to summarize all of three chapters' key points and conclusion in order to get the full picture of my paper.

First of all, it is hard to overestimate the importance of scientific researches, developments and innovations as the whole in the Information Technology sector, which involves companies that produce software, hardware or semiconductor equipment, companies that provide internet or related services etc. R&D has become vitally important for IT corporations and this is an explanation of such huge investments in Research and Development process and innovations. The amount of *annual* expenditures on Research and Development innovative projects by IT companies such as Apple Inc. or Alphabet Inc. is frequently higher than $ 5-6 billion. And these sums are still steadily growing from year to year, the number of R&D projects and their expenditures are increasing as well regardless crises and economic instabilities. Unfortunately, even so large volume of spending on R&D and innovations still does not guarantee a high success rate of R&D projects.

Then I have analyzed numerous obstacles and threats during the process of R&D and innovations in regards to companies representing Information Technology sector. At first, it seems like most of difficulties (such as project financing or the advertisement of a promising product) relate only to small and medium companies, while big market leaders do not experience a lot of problems at R&D and it seems they should have rather higher success rate of such projects. However, this is far from

the case – I have proved otherwise providing corresponding data and statistics showing rather low success rate, billions of dollars spent to nowhere. Also, I gave a number of famous examples considering failed projects of companies like Apple, Amazon or Samsung. All of that has clearly proved an assumption of that there is a lot of space for a potential growth and improvement for Research & Development and innovations industry as a whole.

In the last chapter I have analyzed the system or Research and Development process evaluation which includes technical, economic and other effects. In spite of risks and threats of the innovation process, which were divided into internal and external factors, my proposed recommendations, which are aimed at the increase of the success rate and to improvement of Research and Development projects' effectiveness were divided into Cost-efficiency drivers and Productivity boosting drivers. Cost-efficiency drivers are related to the cost and labor reduction tools, time-saving instruments and so on and implied tools aimed at the reduction of material costs, the reduction of labor costs, the saving of capital investments and time-saving instruments. The second type of drivers is rather less explicit: it implies project management and organizational structure improvement tools such as the analysis and improvement of previous failed projects, risks reduction, the internal innovation project management, strategies and methods of projects' commercialization and state-level factors making product successful.

To sum up, in order to save their investments, to increase innovation projects success rate and to decrease the number of failed or delayed projects, companies which conduct a Research

and Development processes, always have to analyze previous innovation products, whether they were successful or failed, reduce risks related to innovation product and intellectual property, pay a special attention to the internal project management keeping in mind the importance of an innovation project management team.

And vice versa it has to avoid neglection of any kind of slow structures within the Research and Development departments; it has to overcome the problem of a lack of market orientation, analyzing its customers more precisely instead of emphasizing technological processes only as well as to overcome the wrong decision making issue which is usually caused by a lack of a corporate and innovation strategy.

Last and one of the most important point is that every corporation has to avoid underestimation of a process of environment selection as well as a process of innovation product commercialization.

Thus, the tasks set in the beginning of the paper (namely, the analysis of the current situation in regards to investments in R&D and innovations by IT companies, data provision showing the current success rate of innovation projects, presentation of unsuccessful and abortive famous cases of innovation projects, the analysis of R&D process evaluation system, the analysis of companies' experience regarding improvement of R&D efficiency level) are successfully completed, so that the central objective of the paper, which is a provision of recommendations aimed at the increase of the level of effectiveness of R&D at IT companies, is successfully completed as well.

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