



VILNIAUS GEDIMINO TECHNIKOS UNIVERSITETAS

VERSLO VADYBOS FAKULTETAS

ĮMONIŲ EKONOMIKOS IR VADYBOS KATEDRA

Milda Senionytė

**THE RESEARCH OF FACTORS IMPACTING INNOVATION
ACTIVITY IN CONSTRUCTION SECTOR**

**VEIKSNIŲ, DARANČIŲ ĮTAKĄ INOVACIJŲ PLĖTRAI STATYBOS
SEKTORIUJE, ANALIZĖ**

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Katedros vedėjas

(Parašas)
prof. habil. dr. R. Ginevičius
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Milda Senionytė

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Vadovas Doc. Dr. R. Korsakienė _____
(Moksl. laipsnis/pedag. vardas, vardas, pavardė) (Parašas)
(Data)

Konsultantas _____
(Moksl. laipsnis/pedag. vardas, vardas, pavardė) (Parašas)
(Data)

Konsultantas _____
(Moksl. laipsnis/pedag. vardas, vardas, pavardė) (Parašas)
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Milda Senionytė, 20053598

(Studento vardas ir pavardė, studento pažymėjimo Nr.)

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(Parašas)

Milda Senionytė

(Vardas ir pavardė)

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ĮMONIŲ EKONOMIKOS IR VADYBOS KATEDRA

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(Parašas)
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(Vardas, pavardė)

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Baigiamojo darbo rengimo konsultantai.....
(Moksl. laipsnis/pedag. vardas, vardas, pavardė)

Vadovas
(Paraša)

Doc. Dr. R. Korsakienė
(Moksl. laipsnis/pedag. vardas, vardas, pavardė)

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.....
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Autorius **Milda Senionytė**

Vadovas **doc. dr. Renata Korsakienė**

Kalba: anglų

Anotacija

Šiame baigiamajame magistro darbe tiriami veiksniai, kurie gali daryti įtaką inovacijų plėtrai Lietuvoje. Šio darbo tikslas - išskirti pagrindinius veiksnius, kurie daro įtaką inovacijų plėtrai statybos sektoriuje, įvertinti šiuos veiksnius pagal svarbą ir reikšmingumą. Darbo tikslui pasiekti keliama uždaviniai:

- └ Apžvelgti inovacijų padėtį Lietuvoje, palyginti ją su kitomis EU valstybėmis;
- └ Analizuoti mokslinę literatūrą, susijusią su inovacijomis;
- └ Atliekant literatūros analizę, išskirti veiksnius, kurie daro įtaką inovacijų plėtrai, ir kurie bus panaudoti tolimesniam darbo tyrimui;
- └ Apžvelgti Lietuvos statybos sektorių;
- └ Atlikti ekspertinį vertinimą, naudojant anketavimo metodą;
- └ Analizuoti gautus duomenis ir nustatyti veiksnių reikšmingumą;
- └ Išrinkti geriausią alternatyvą ir išnagrinėti veiksnius, kurie darė jai įtaką.

Magistro darbą sudaro įvadas, trys dalys, išvados ir pasiūlymai. Pirmoje dalyje yra apžvelgiama inovacijų padėtis Lietuvoje, palyginama su kitomis EU šalimis, išskiriamos pagrindinės problemos. Antroje dalyje nagrinėjama mokslinė literatūra ir Lietuvos Statistikos departamento duomenys. Šioje dalyje išskiriami pagrindiniai veiksniai, kurie bus vėliau naudojami tyrime. Trečioji dalis apima visą tyrimą - apžvelgiamas statybos sektorius, aprašoma pasirinkta tyrimo metodika, atliekamas tyrimas, pateikiami visi skaičiavimai bei pateikiami tyrimo rezultatai. Pabaigoje pateikiamos išvados ir pasiūlymai. Darbo apimtis – 67 psl., 13 iliustracijų, 14 lentelių, 69 bibliografiniai šaltiniai. Atskirai pridedami darbo priedai

Prasminiai žodžiai

Inovacijos, veiksniai, skatinantys inovacijas, darantys neigiamą įtaką, inovacijų plėtra, COPRAS, alternatyvos, ekspertinis vertinimas

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Author **Milda Senionytė**

Academic supervisor **Assoc Prof Dr Renata Korsakienė**

Thesis language:
English

Annotation

This master thesis examines factors, which may impact innovation activity in Lithuania.

The purpose of this research is to identify the key factors, which may impact innovation activity in the construction companies, to evaluate these factors and rank them by importance.

Thesis' tasks are as follows:

- ┌ Review of Lithuania's innovation performance, comparing it with other EU countries;
- ┌ Review of the literature associated with innovations;
- ┌ During the literature review, identify factors, impacting innovation activity, which will be used for further research;

- ┌ Review of Lithuanian construction sector;

- ┌ Make experts research, using a questionnaire method;

- ┌ Analyze gathered data and determine the importance of the factors;

- ┌ Select the best alternative and analyze the factors, affecting it.

Master thesis composes out of introduction, three parts, conclusions and recommendations.

In the first part is review of Lithuania's innovation performance, comparing with other countries and highlighting the main problems.

Second part includes the analysis of science literature and data from Lithuanian Department of Statistics. In this part the main factor will be identified and used for further research.

The third part is devoted for the research – short review of construction sector, research methodology, research, calculations and results. At the end of the thesis the findings and recommendations of the science literature and research are given.

The volume of the work – 67 pages, 13 illustrations, 14 tables, 69 bibliographical sources. Appendixes included.

Keywords

innovation, factors, barriers, drivers, development of innovation, COPRAS, alternatives, expert evaluation

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INTRODUCTION

Nowadays, the pace of life is very high, people's needs and expectations are growing and evolving in every day, so the main task for markets – to offer the attractive products and services, which would satisfy the customer. In order to offer such products, companies have to constantly improve the characteristics of product, to create and implement new products or services.

The word “innovation” becomes more popular among the companies, which seek to ensure the good and leading position in the market and to meet market trends. Innovation is the ability to absorb new ideas and turn them into commercial product or service, using new processes (or improved processes) in ways which are better and faster than market competitors. The competitive advantage of company strongly depends on its' possibility to benefit from innovation activity. Innovations are essential for company's growth.

Lithuania's innovation performance, comparing with other European Union countries, is weak. Lithuania is significantly below the EU27 average and assigned to “Modest Innovators”. Development of innovation makes country more competitive among the international markets and more attractive to foreign investments. It is necessary to improve and to strengthen Lithuania's innovation performance.

There are considered a lot of external and internal factors, which may impact innovation activity among the companies. Different authors identify different factors. During the literature review, the key factors will be identified and analyzed.

The construction sector was chosen to be analyzed, because this is one of the most important in the modern economic. Moreover, this sector is the less innovative, comparing with other sectors. The need of innovation in the construction sector is well recognized.

The identified problem is weak innovation performance in Lithuania, comparing with other countries, and in construction sector, comparing with other sectors. According to fact, that Lithuania's government pays more attention to innovation development – new funding sources, programs, supporting innovations among the companies, research institutes, reduced taxes for innovators and etc; Lithuania's situation should be better, than this is now. The **research problem** is to identify the factors, which are hampering innovation activity within the construction companies.

The **objective** of this work is to select the most important factors for the research.

The **purpose** of this research is to identify the key factors, which may impact innovation activity in the construction companies, to evaluate these factors and rank them by importance.

Thesis' tasks are as follows:

- ✓ Review of Lithuania's innovation performance, comparing it with other EU countries;
- ✓ Review of the literature, associated with innovations;
- ✓ During the literature review, identify factors, impacting innovation activity, which will be used for further research;
- ✓ Review of Lithuania's construction sector;
- ✓ Make experts research, using a questionnaire method;
- ✓ Analyze gathered data and determine the importance of the factors;
- ✓ Select the best alternative and analyze the factors, affecting it.

Master thesis composes out of introduction, three parts, conclusions and recommendations.

In the first part is review of Lithuania's innovation performance, comparing with other countries and highlighting the main problems.

Second part includes the analysis of science literature and data from Lithuanian Department of Statistics. In this part the main factors will be identified and used for further research.

The third part is devoted for the research – short review of construction sector, research methodology, research, calculations and results.

At the end of the thesis the findings and recommendations of the science literature and research are given.

1. THE REVIEW OF LITHUANIA'S INNOVATION PERFORMANCE

The development of innovations is one of the most important factors, which increases the country's competitiveness in international markets. Innovations make the country to be more attractive and interesting to foreign investors.

The biggest problems of Lithuania's competitiveness were analyzed in "Inovacijų skatinimo politikos vertinimas" report, prepared by Public Policy and Management Institute. These problems are:

- low level of technologies in industrial structure;
- low labor productivity;
- lack of direct foreign investment in high value-added sectors;
- disagreement between high education and industry needs and lack of qualified specialists, their emigration to other countries;
- big gap between business and education sectors;
- lack of knowledge-based entrepreneurial culture;
- practically non-existing ability to transform knowledge into the intellectual capital;
- low level of absorptive capacity.

Development of innovations in Lithuania could be effected by these factors:

- Decreased investments in innovations and technological modernization – due to economic crisis, markets became tightened and as a result, the profit of business companies' has sharply decreased.
- Reducing the budget deficit by increasing taxes. Companies financial resources were reduced, and this led to less investments in innovation and development;
- Private funding institutions has tightened their conditions to get financial loans;
- Lithuania's society is considered to be conservative and little susceptible for innovations. The crisis had decreased the demand of innovative products.

The number of innovative companies is different among the whole Europe. The below is provided Europe map (Figure 1), and all countries (and regions) are divided there into five groups – high innovators, medium-high innovators, average innovators, medium-low innovators and low innovators. This map clearly describes the innovative countries across the Europe. The darkest colour represents the most innovation, whilst the lightest colour represents low innovation; the other shades denote level of innovation in relation to strength

of colour. The high innovators zone is located in Finland, Sweden, England, Denmark and Germany. Lithuania is considered as country with medium – low innovators (Lithuania’s neighbors - Latvia falls into low innovators zone, and Estonia – into average innovators zone).

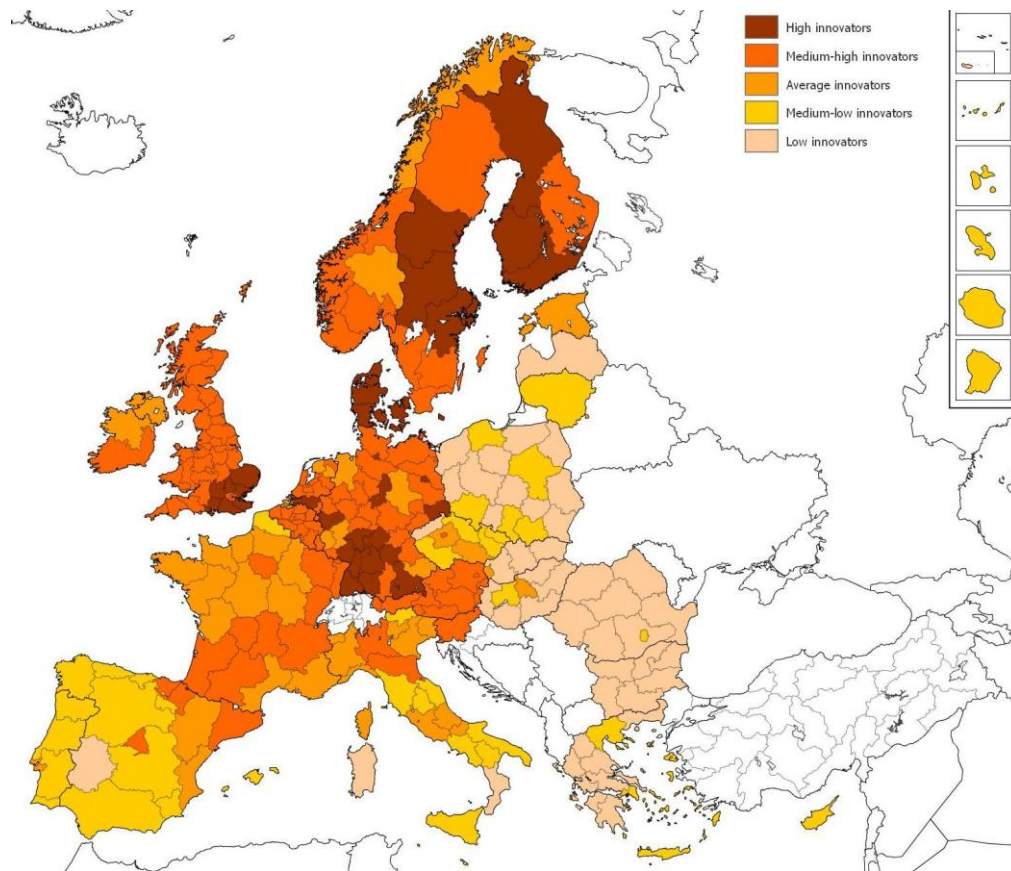


Figure 1. The map, showing levels of innovation across the Europe.

Source: Regional Innovation Scoreboard (RIS), 2009.

Lithuania’s position in innovations in regional, international and global levels is weak. Although, Lithuania has a good geographical situation – near the Baltic Sea, where are located high innovator countries – Denmark, Sweden and Finland – cooperation with these countries can speed up the development of innovation in Lithuania.

The newest “EU Member States’ Innovation Performance” (Figure 2) shows, that Lithuania is significantly below the European Union (EU) level of innovation performance, as other countries - Latvia, Romania and Bulgaria are below of the EU27 average too. These countries are considered to be “Modest Innovators”.

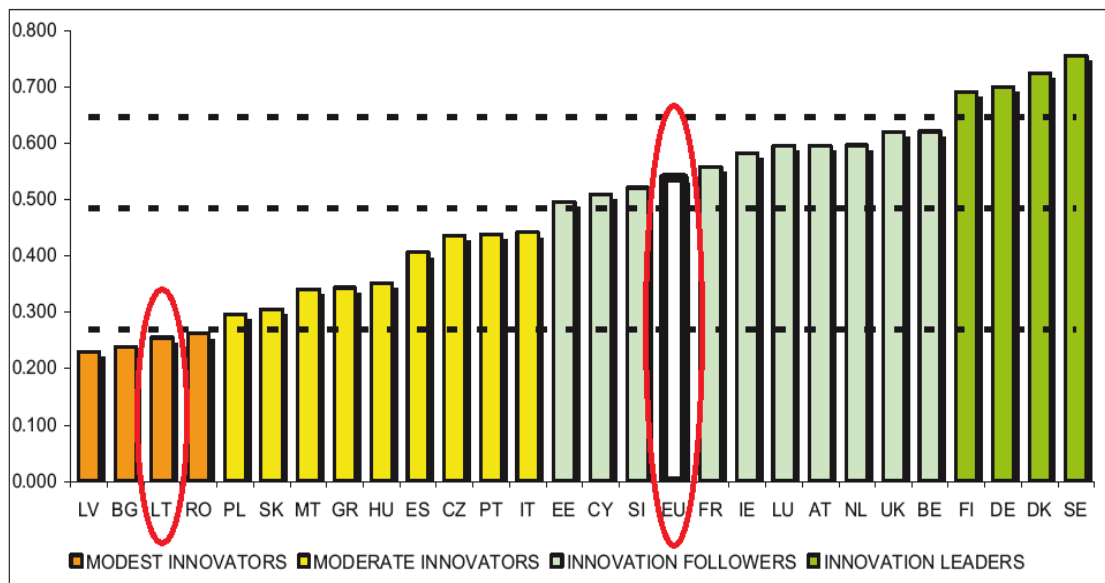


Figure 2. EU Member States' Innovation Performance.

Source: Innovation Union Scoreboard 2011.

As it is shown in Figure (3), Lithuania has a very small number of indicators, which are higher than EU27 average. These indicators are “Population aged 30-34 completed tertiary education”, “Youth aged 20-24 upper secondary level education”. The problem is that indicator “New doctorate graduates” is below EU27 average, this means, that Lithuanians are among these, who do not study the whole life – usually they finish secondary school, get bachelor degree and master degree – there is no need to continue their learning. To summarize this Figure (3), relative strengths are in Human resources and Finance and support, and the weakness is in Open, excellent and attractive research systems, Linkages and entrepreneurship, Intellectual assets, Innovators and Economics effects.

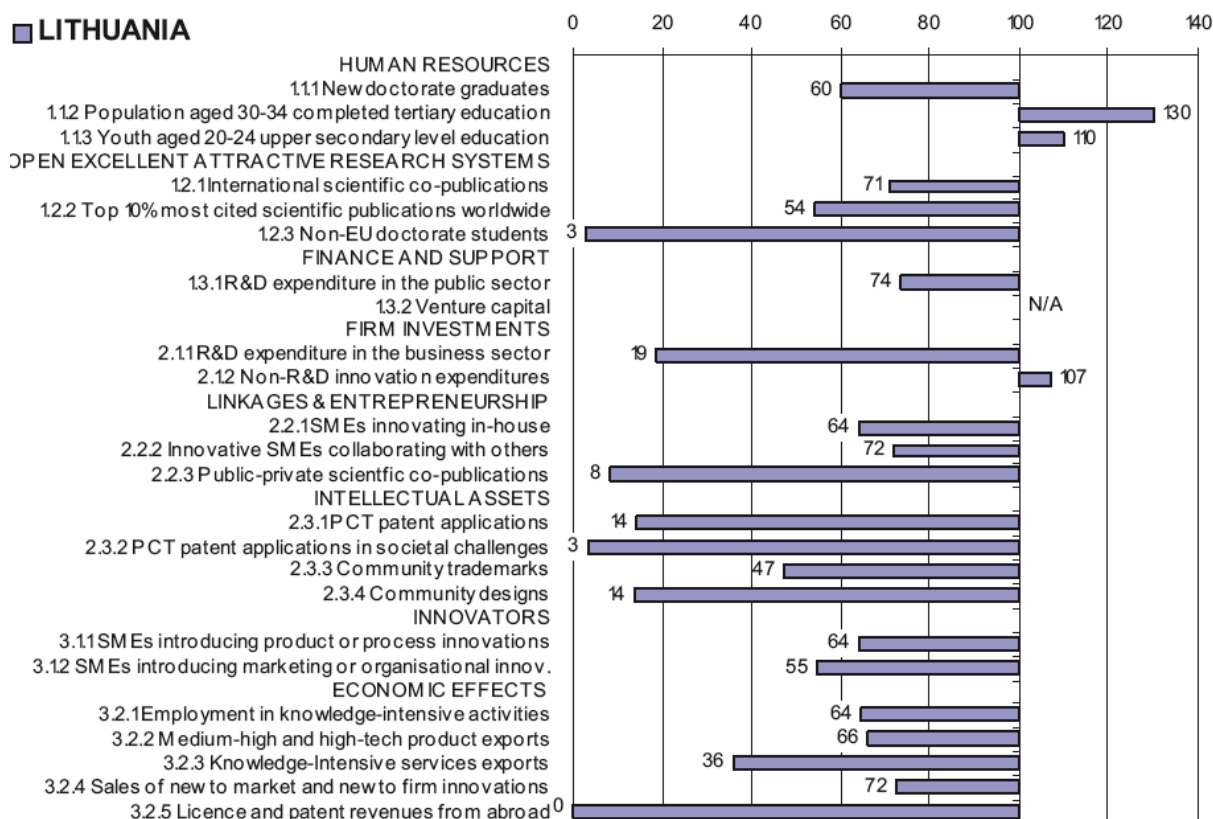


Figure 3. Indicator values relative to the EU27 (EU27=100)

Source: Innovation Union Scoreboard 2011.

According to the Ministry of Education, the fields on which Lithuania should concentrate in order to improve the results of innovation implementation include economic impact, intellectual resources, business relations and entrepreneurship as well as the openness and attractiveness of the scientific research system.

Lithuanian Department of Statistic empirical research “Development of Innovation Activity 2010” notes that in 2008–2010, innovation activities in Lithuania were carried out by 32.5 per cent of enterprises. Innovative enterprises employed 51.2 per cent of the total number of employees, while their turnover made up more than half of the turnover of all enterprises (in 2008, 64.2 per cent; in 2010, 65.8 per cent). Innovation activities were carried out by 69.6 per cent of large (250 and more employees), 43.1 per cent of medium (50–249 employees), and 27.9 per cent of small (10–49 employees) enterprises.

2. FACTORS IMPACTING INNOVATION ACTIVITY – THEORY REVIEW

The economic has strongly changed during the last ten years. In each day arise a lot of new technologies, products, services and etc. Intensive development of current technologies, creation of the new technologies and growth of human needs lead to a wide range of innovation use.

2.1. The concept of innovation in scientific literature

A lot of authors give a different definition of innovation, but the essence is the same of all definitions. Creating and developing a new innovation, there arise and different strategies (types) of innovation. The selection of innovation strategies depends on many factors: innovation of the new one (new product, new technology), or it is only improvement of already existing product or process; a size of wanted and expected profit; the main aim of innovation (to be the first in a given sector with a new product or process, to reduce the costs of the production, to show new advantages of the product, which is already existing in the market, etc.); the market penetration rate and etc.

Regarding the economic crisis situation the whole economic sectors had strongly changed – many companies were in bankruptcy, other companies were trying to save cost, for the reason to survive in this difficult period. However, not all the companies were having difficult period – some of them started to invest in innovations in spite to become stronger and to become the biggest player in the market. Many people say that financial crisis is the best way to get the maximum benefit and return from investments in innovation.

Different authors provide the different definition for innovation and this does not mean that some of them are correct, and others are in-correct. Every company, which is interested in innovation, mentions it only in meaningful context for this company, but definition may differ from any other group definition, formulated under the different context.

The definitions arrived from literature are as follows:

Innovation consists of the generation of a new idea and its implementation into a new products, process, or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise (Kagono, 1988).

Innovation encompasses the way in which firms and entrepreneurs create value by exploiting change. Change can be associated with technological advance, but also with

modifications of the regulatory framework of an industry, shifts in consumers' preferences, changes in the demographic makeover, or even major alterations of global geopolitics (Conceicao, 2005).

Innovation occurs in many fields such as fine arts, engineering, politics, the business world and many more. In economics, innovation defines a change in products or processes that increases consumer rent, producer rent or social welfare (Harold, 2008).

Innovation is the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change (Slaughter, 1998).

There are given such forms of innovations:

- Scientific innovation – a successful creation of scientific innovation, adaptation and use in various fields;
- Managerial innovation – changes of management, work organization and work conditions. These innovations are very popular among the companies, which is not producing. For example, the Real estate companies, which are renting premises. During the crisis such companies were trying to change their strategies in management – they invested in improvements of employees; they were trying to improve rental conditions and etc.
- Technological innovation – development of the new technologies, renewal and extension of existing technologies, implementing them in to different areas;
- Industrial innovation – implementation of a new production, supply, distribution and other methods.

The short definition of innovations are: inventing something new, generating only new ideas, improving something that already exists, spreading new ideas, adopting something new that have been successfully tried elsewhere, performing something in a new way, following the market, attractive innovative people, seeing something from a different perspective (Goswami, 2005).

Summarize these definitions of innovation, the aim of innovation is the use of research results and inventions on purpose to develop and upgrade the products (processes) nomenclature, improve technologies and their production.

2.2. The types of innovations

In nowadays, companies may follow three types of innovation (sometimes called as strategies):

1. *May seek to innovate (disruptive innovation)* (Cooper, 1994). Degree of innovation can be from radical to increasing. When radical innovation is presented to the market, it may seem, that it is has not produced as it was expected, but after, it can become popular and its' adoption can widely spread. In example, Apple's introduction of the personal computer was a radical innovation. When IBM introduced its first PC several years later, the innovation was less radical (Gilbert, 1994). According to Zakic *et al* (2008), radical innovations potentially offer huge profits and competitive advantage, but demand considerably higher risk level, company effort and resource engagement.

2. *May continue with the older products or processes (breakout innovation)* and seek other advantages, which can reduce the operating costs, make product more competitive or exclusive (Cooper, 1994). Firms seek to gain one or another of these advantages is sometimes referred to as first movers. Those that do not aim for invention, but innovate by adopting an invention that appears to be a winner, can be said to be late movers. Even if an innovation is clearly incremental rather than radical, the first mover is introducing or seeking change to a greater degree than the late mover, who waits until an invention no longer seems new to the market or the industry before adopting it. Late movers, who introduce an innovation because many competitors already have it and who will lose sales unless they introduce one too, are obviously toward the late end of the continuum (Gilbert, 1994).

3. *May imitate products and processes (sustained innovation)*, purchased from innovating companies (Cooper, 1994). Innovations that are technologically inventive generally require more time and effort to develop than those that are technologically imitative. Innovations that are perceived as imitative by the customer lend themselves to perceptions of stability, whereas those seen by the customer as inventive foster a perception of change (Gilbert, 1994).

The main purpose of formulating the innovation strategy is to find the best way to achieve the biggest results by increasing its' total value. The category of value expresses not only the economic aspect – not everything is mainly involved in profit, because an organization is a complex of a difficult various objectives and interests.

2.3. Participants in innovation process

According to Blayse and Manley (2004), innovation process includes a wide range of participants. For example, in construction sector, it includes government, building material suppliers, designers, general contractors, specialist contractors, the labour workforce, owners, and private capital providers, end users of public infrastructure, vendors and distributors, testing services companies, educational institutions, certification bodies and others.

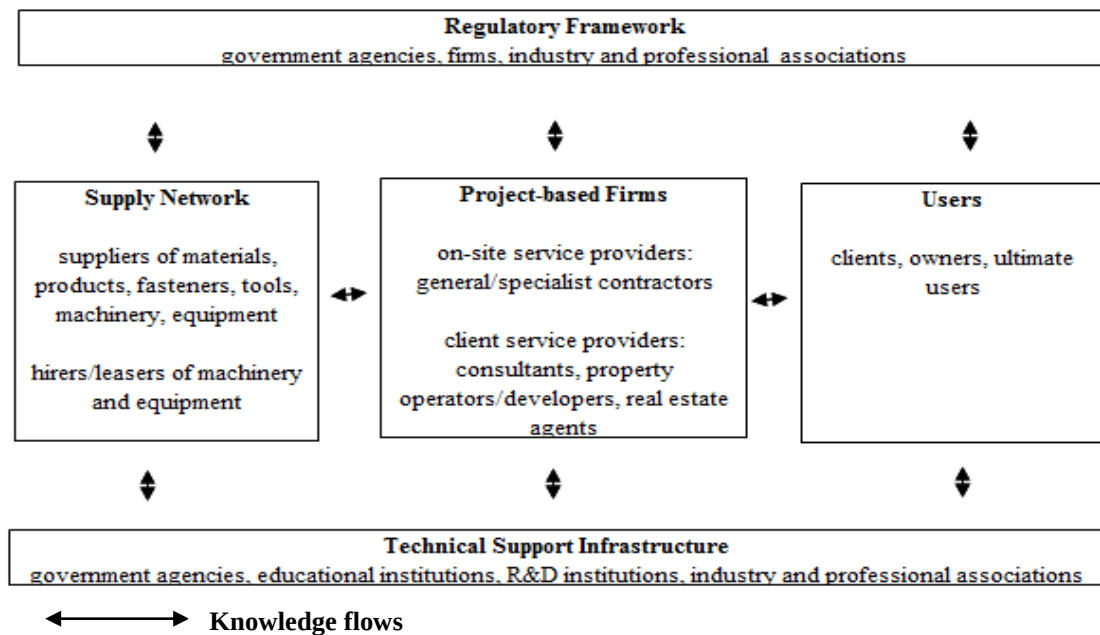


Figure 4. Participants in the building and construction project system

Source: Gann and Salter, 1998.

Figure (4) shows the broad range of key participants in the construction industry and the need for active networking between them (Gann and Salter, 1998).

2.4. Factors, impacting innovation activity

The most important problem in managing innovation activity in the company is uncertainties in the innovation process. Companies have to identify internal and external factors which might affect innovation process in their company. Some of these factors may initiate and motivate to innovate while others can hinder innovations. In the literature these factors may be called as barriers and drivers to innovation activity.

Different literature sources indicate different key factors, which are impacting innovation activity in construction sector. Pellicer, Yepes and Rojas (2010) indicates these

factors, from which depends country's innovative capacity: public policies that facilitate the creation of enterprises as well as scientific and technological research projects, political and economic stability, private investment, laws protecting intellectual property, the public awareness of the advantages of technology, ongoing collaboration between enterprises and universities, and a good quality higher education system.

According to Balezentis (2007), the main external factors, which are hampering innovation activities, are competition in the market, high cost of new technologies, and the lack of qualified specialists. The factors which lead innovation activities – market changes, education system, progress of science and decrease of human resources.

Yng Lyng (2003) presents these barriers that hinder progress of innovations: form of contract, cost of carrying out research, lack of information on cost savings arising from the innovation, restrictions imposed by regulations, contractors and consultants are isolated from each other, contractors are often of small size and fragmented, there is absence of competitive pressures on non-innovating firms and contractors may be unable to specify their products.

Garcia *et al* (2009) has established barriers, which can impact innovation activity. These barriers are presented in Figure (5).

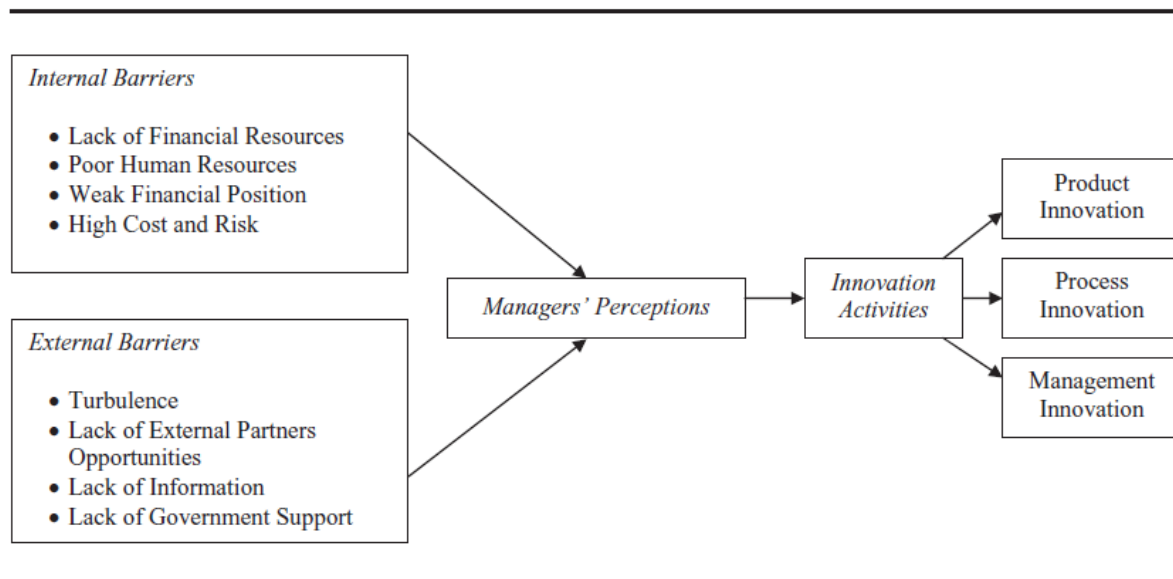


Figure 5. Barriers to innovation activity

Source: Garcia *et al* (2009).

In the Lithuanian Department of Statistic empirical research “Development of Innovation Activity 2010” are indicated factors, hampering innovation activity. These are – low demand for innovative or services, markets dominated by established enterprises, difficulty in finding cooperation partners for innovation, lack of information on markets, lack of information on technology, lack of qualified personnel, innovation costs too high, lack of

finance from sources outside the enterprise, lack of funds within the enterprise or enterprise group.

The key factors impacting innovation activity according to literature are:

1. **Customers.** They have a huge impact for the construction firms in a way that leads innovation. According to Zakic *et al* (2008), orientation to customers needs and their satisfaction are well-known concept in the field of a Total Quality Management. The companies oriented to customers are responsive to final customer needs, measure their satisfaction level and improve the processes in order to satisfy customers. Clients have many ways to influence the innovation in construction. They may request to be more flexible on terms of time, to provide more unique product or service than other companies, to present better quality of construction work and materials, to give lower cost (but with the same quality as other companies can offer), to improve other characteristics of the building and other requirements, that may differ regarding the client needs and priorities. Usually constructions companies are ready to compete for the customers; especially in nowadays then supply exceeds demand. The more experienced are client in construction sector, the more likely that he would impact companies to seek for new types of innovations. According to Hartmann (2006), the dependency of constructional tasks on clients leads to the fact that to a certain extent each constructional task has to be responsive to the specific requirements of a single client.

Focus on existing customers can limit a company aptitude to innovate because managers are not keen on serving new users (Zakic *et al*, 2008). In purpose to attract the client, companies have to offer different kind of service or product, than competitors offer. These lead to look for a new ways to reduce the cost, to offer a new design – to seek for new innovations.

2. **Manufacturers.** Manufacturing firms also are considered as factor, which impact construction innovation. Manufacturing firms tend to operate in more stable and standardized markets than do contractors and consultants, allowing them to maintain research and development programs (Blayse and Manley, 2004). These firms are more innovative then construction firms, they often provide new innovative components that are installed into the building (such as new heating, air-conditioning systems and etc). According to Bossink (2004), building material manufacturers and retailers providing information about new products take away the designers' and contractors' uncertainty about the new possibilities and contribute to innovation in the industry.

3. **High cost.** According to Garcia *et al* (2009), cost has been considered as one of the most significant barriers to innovation. It is known, that new technologies, new researches, hiring new experts is more expensive than existing ones. In the research, carried out by Lithuanian Department of statistics, the high innovation cost was indicated as the main factor, hampering innovation activity. This factor was indicated by the 29.6 per cent of all enterprises.

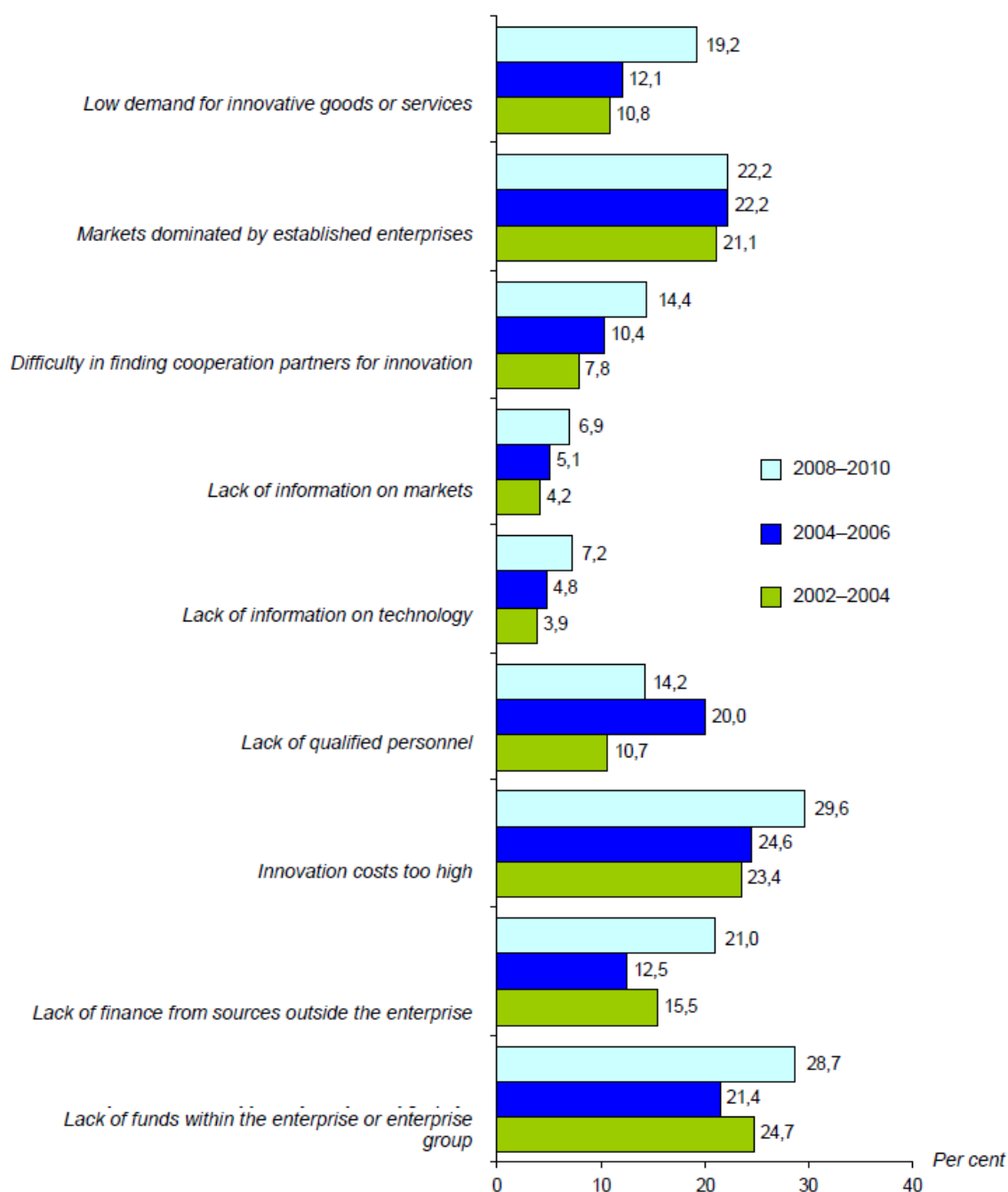


Figure 6. Factors hampering innovation activity

Source: Lithuanian Department of Statistic.

Cost can be related with another factor, which is impacting innovation – funding. The role of financial exposure and cost of innovation may thus be important constraints on innovation (Garcia *et al*, 2009). If innovation cost is high, companies more carefully think about implementing this innovation and financing innovation with debt. In this case, having debt prevents company from other activities, such as improvement of working conditions, purchasing of new equipment and etc.

4. **Incorrect measures.** For many organizations, revenue, profit and market share are the only measures used. These are easier to quantify than intangibles such as reputation, knowledge, attractiveness to talent, leadership and other assets that make major contributions to the true value of an enterprise (IBM, 2006). Also the large numbers of investors pay little attention to the management of the companies in which they invest - they are more focused upon how much profit they will obtain from their investments (Benmansour and Hogg (2002).

5. **Competition.** Firms in more turbulent external environments have higher potential for innovation, because turbulent environments trigger firms to incorporate innovation into their business strategy in order to remain competitive and, ultimately, survive (Garcia *et al* 2009). According to Wziatek-Kubiak *et al* (2010), the more competition firms face, the higher the likelihood they also face cost, labour and other problems, for example expertise-related problems. This suggests that the barriers to innovation are strongest when competition is at its highest level or that the most innovative firms are those which perceive impediments to innovation most strongly. Many players seek a first-mover advantage, using innovations to create products or process improvements in large, established markets or access an untapped market segment. Being the first to market with a proprietary technology can create an opportunity to generate revenue in this early phase of market development (Blockley and McDowell, 2010). According to Zakic *et al* (2008) the market concentration is a stimulus to innovation.

6. **Risk.** Companies, which are implementing new innovations, always face the risk. The risk can occur in every step of innovation process. According to Andrews (2005), no progress is made without calculated risk-taking. Since people know that innovation is risky, many people run away from it. In fact, some organizations habitually play the game of finding things that could go wrong (IBM, 2006). Due to Johnson (2010), innovations often suffer from a liability of newness as, by definition, they are new, untested and present many early adopters with an inherent notion of being high risk. According to Jukniene (2006), there can be risk due to lack of innovative project funding. The chosen funding source should be reliable and will not end at the certain stage of innovation process. Also there can be risk that

company could not find the investor. There also can be risk in cooperation process – company may incur losses if its partners miss the deadlines, partner can become incapable or insolvent, and if company has already invested in innovative project, it has to seek for alternative partners, suppliers or buyers. According to Hardie (2010), the lack of trust between the contracting groups on projects can lead to a hard line reliance on the letter of the contractual law to apportion blame rather than to solve the problem. Sometimes the project requires special equipment or material – it may be difficult to find suppliers in local market, so companies need to seek in other countries for the supplier, which represents the additional cost and risk. The same situation arises when supplier does not comply with terms or quality requirements. Companies may face the competition risk, then leak of confidential information on employees' fault or due to industrial espionage, which took the competitors. Unreliable information about the market and competitors can impact innovation process also. According to Janger and Holzl (2011), risk barriers to innovation are associated with an excessive reliance on routines and experience and an unwillingness to cannibalize the own product markets. Disruptive innovations often threaten the existing products of established firms.

7. **Demand.** Some authors do not exclude this factor as a separate one. The client needs and demand are closely connected. Zakic *et al* (2008) states, that demand undoubtedly affects innovation activities. Benefits that innovations bring are proportional to the market size. Companies can rather decide to take up innovations if they assets that selling potential is high enough. The most important characteristics of the demand that a company should consider are: selling potential, demand growth, demand length, demand indefiniteness and demand elasticity. According to Keršys (2008), when demand is growing, it leads new companies to enter the market and grow the existing ones. The demand stimulates technological changes in the market.

Lithuania's market is very limited; it is likely that companies, which are oriented to the global markets, are more interested in innovation activities.

8. **Company size.** According to Holzl and Janger (2011) this is an important factor. The ability of firms to create, access and commercialize new knowledge, new financing and new skills is fundamental to sustained growth at the firm level. Small companies have more difficulties and barriers than large firms to access and absorb the knowledge, to establish collaborations required for their innovation activities. Larger firms are better equipped with internal innovation resources and expertise, are better able to finance R&D (research and development) from internal sources, are able to reap the rewards from innovation, and can diversify the risk of introducing innovation (Wziatek-Kubiak *et al*, 2010). On the other hand,

small companies are more flexible and can improvise more in the task. According to Heimonen (2012) large firms are more likely to seek patent protection.

9. **Funding.** Funding is very important factor for development of innovation activity. A lot of research carried out that one of the main barriers for companies to innovate is too high cost and lack of funds within the enterprise or enterprise group. According to Ozmen and Saatcioglu (2010), “finance of innovation” has strong driving power and is classified as independent variable.

According to Benmansour and Hogg (2002), the most important aspect of innovation relevant to the financial system is its requirement for finance to accommodate a range of resource needs including physical capital, research and development, training and marketing.

Funding sources for innovations are different than for other activities, because innovation is related with high risk and banks often refuses to fund it. There are different kinds of sources and it depends on several factors which to choose: from the stage of the innovation project development, from the company size, from the amount of required sources and etc. There are funding sources:

- 9.1. Personal, family or friends savings. This source can be used only in the beginning of the innovation project (for researches, consultations and etc.). The further steps of innovation process require bigger amounts of funding sources. It is estimated that one euro, which is invested in research, needs 10 Euros invested in business development stage and another 100 Euros in phase of exploitation (“Inovacijų finansavimo galimybių apžvalga”, 2012).
- 9.2. Government support and European Commission Funds. The country’s economic growth leads to innovations, and therefore the government is interested in supporting the innovation activities. One way of providing the financial aid is the provision of the grants. These grants are provided through the variety of government support and EU funding programs. The government also helps companies to obtain loans by providing financial guarantees. The government also support by reducing taxes for innovative companies.
- 9.3. Other companies. The whole business sector, in order to survive and stay in the market, has to renew constantly. This makes them not only just create innovations, but also invest in other companies, which are carrying out innovative research. Such kind of investment is one way of funding sources for small and medium-sized companies, because other investors due to the high risk try to avoid invest in research.

9.4. Informal investors – “Business angels”. They can finance the establishment of the company as shareholders and directly consult company on management issues. “Business angels” are wealthy people, who are willing to invest their capital into the risky activities, based on their experience and interests. Normally these investors previously held management position in the large company or have already sold the other company’s shares and willing to invest their capital in other activities. “Business angels” motivation and aim can be very different. Usually they invest in these sectors, which are well known for them and in which they have more work experience. “Business angels” pay more attention to enterpriser’s personal characteristics. Usually they do not invest more than 250 thousand Euros. “Business angels” funding may be provided in all primary stages of innovation activity before starting intensive exploitation of innovation.

Only since 2005, in Lithuania, was established the first network of “Business angels” – till that period there were no possibilities to find the official “Business angel” or such type of investment opportunities. This project was initiated by public institution “Sauletekio slenis”. The main aim of this project was to fill the existing information gap between entrepreneurs, who are looking for financial support to set up their own business and investors, who are looking for promising investment projects.

There was established European “Business angels” network (EBAN) in 1999. This non-profit organization seeks to promote the exchange of experience and best practice among networks of “Business angels”, to support the recognition of “Business angels”, to contribute to local, regional and national programs that support creation and development of business-friendly environment.

9.5. Venture capital funds. These funds support innovation activity then product prototype is already created or trial production has already begun. Venture capital funds can also support establishment of the new company or new innovative projects in already existing companies. Usually these funds invest in company’s shares and hope that this company will be successful and its value will significantly increase in the market. If such scenario happens, these venture capital funds seek to sell this company’s shares and get profit. The main task for venture capital funds managers is to identify companies, which have real perspectives to growth, and to support them with the necessary financial injection for further development. Majority of venture capital funds are focused on large transactions (more than 250 thousand Euros). In Lithuania there are some venture capital funds – SEB Venture Capital, Hermis

Capital, Hanseatic Capital, Middle Europe Investments, Finnfund, Swedfund International and more others.

9.6. Commercial banks and investors. These funding sources get involved in the last stages of the innovation processes – where the risk has decreased significantly. There appears more willing to invest after innovation is introduced in the market and highlights the potential profitability. On this stage, commercial banks provide loans easier; there appears opportunity to offer the company's stock exchange. According to Zakic *et al* (2008), it is bigger possibility that bank will finance process than product innovation. Projects of product innovation are considered to be less definite, with more freedom and smaller commercial performance. Also, there is a bigger possibility and opportunities for the large companies to get loan, than for small enterprisers.

10. Regulations/standards. It is very important that selected innovations would not be against the law and standards. According to Benmansour and Hogg (2002), the term regulation refers to the political and legal actions a government may consider necessary to oversee market activity and the behavior of private actors in the economy. Good regulation specifies the outcome to be achieved and provides industry with sufficient lead-time to apply initiative and innovation to meet that goal in the most cost-effective manner (Department for Business Enterprise & Regulatory Reform [BERR], 2008).

Innovation policy is a combination of instruments and measures, thought which the government seeks to make conscious impact to innovation processes. It is important to note, that despite whether the government has distinguished tasks of innovation policy or not, its' decisions makes huge impact to creation of innovations and diffusion.

According to Benmansour and Hogg (2002), regulations can be divided into tree types – economic, social and administrative. Economic regulation is intended to improve the efficiency of markets in delivering goods and services, social regulation protects the environment and the safety and health of society at large and administrative regulation governs the practical functioning of the public and private sectors.

The main problem is procurement system - which stress lowest price rather than best value (Hardie, 2010). At times, the experience, skill base, safety record and appropriate capitalization of tenders can be ignored in favor of a low tender price from a less reputable firm that may be ultimately undeliverable. This leads to fact that usually innovative companies, which are offering more expensive product, may not be chosen – no matter that their product or service is better then competitors.

In Lithuania all regulations and strategies for innovations are administrated by Ministry of Education and Science and by Ministry of Economy. Ministry of Economy is responsible for innovations in business; Ministry of Education and Science is responsible for innovation growth, development of research and partly of the commercialization of research results.

One of the main document's, which regulates innovations in Lithuania, is "The Lithuanian Innovation Strategy for 2010-2020". The strategic objective is to develop a creative society, to ensure comfortable conditions for innovations and entrepreneurship. The other goals and tasks are – to increase the integration of Lithuania into the global markets ("Lithuania without borders"), to develop creative and innovative society, to develop all kinds of innovation, to establish a systematic attitude to innovations. The below Figure (7) best illustrates all expected steps of this new innovation strategy. It is willing that Lithuania will become a Nordic European Innovation Centre on 2020.

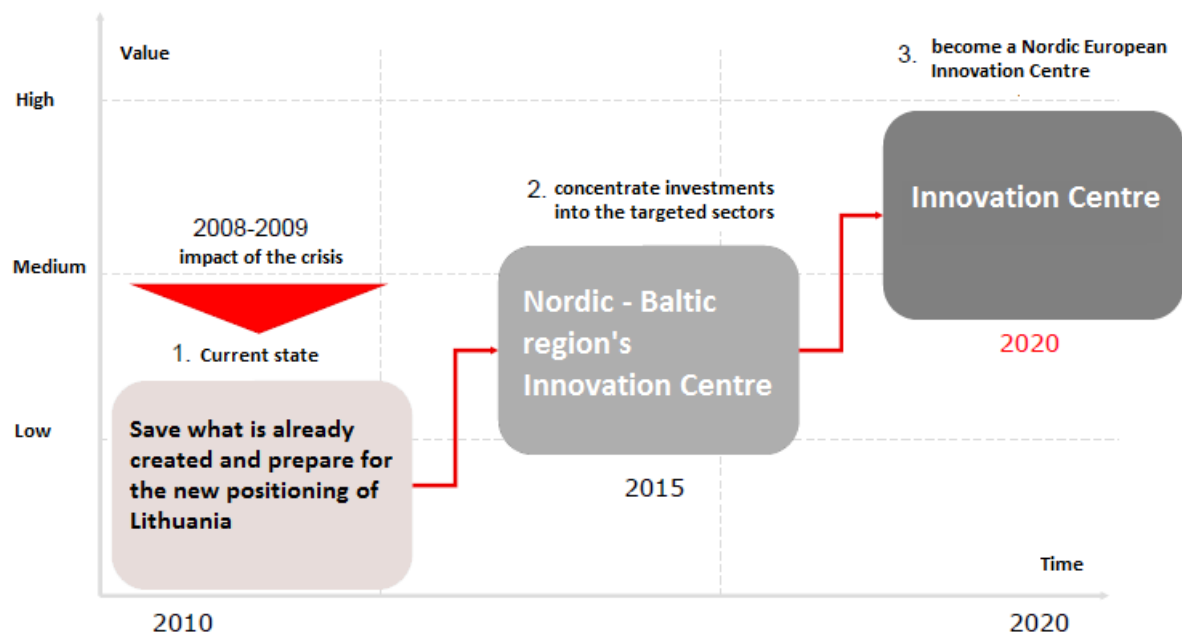


Figure 7. The Lithuania's innovation strategy 2010-2012

Source: Danilevičius (2010).

11. **Staff.** This factor is associated with human resources, because any innovations activity is integral part of creation of new knowledge, production and use, which is mental work. Very important is employee education, qualification (knowledge and experience), attitudes and openness to innovations and motivation (Keršys, 2008). Companies should arrange trainings related to the new market trends, because new technologies can be implemented effectively only by properly trained and skilled employees. According to

Bossink (2004), innovations by workers on the site is highly stimulated when the workers are informed about the products and procedures and get the space to develop their own processing methods to work with these innovations. According to Garcia *et al* (2009) have emphasized the role of employee resistance to innovation based on issues such as poor communication, existing corporate norms, weak human resources practices and lack of commitment of top management. Adoption of innovation requires employee commitment and effort. Constraints arising from weak management support are an innovation choke point because innovation can disrupt established routines and schedules (Garcia *et al* 2009). According to Loewe and Dominiquini (2006), companies that involved many employees had better innovation results than companies that involved few people.

The main factor, related with staff, which is hampering innovation activity – lack of qualified employees. Those, who are considered as qualified expert, usually emigrate to another country, because they can get better conditions to work, more self-expression.

12. Information and knowledge. Effective information gathering is an important innovation driver (Bossink, 2004). According to Blayse and Manley (2004), it is important that firms involved in construction attempt to codify knowledge acquired on projects so it can more easily flow between projects. Companies, which are seeking to implement any kind of innovation, have to continually collect and analyze information, which includes not only information about this new innovation, but also includes information about the marked trends, customer needs, economical situation, new regulations and standards, competitors and their planned actions, new possible funding sources and etc. Filling this information can help enterprises to reduce the risk of implementing innovation, prepare for further actions. Information about technology, markets, and government policy initiatives can reinforce the importance and potential advantages of becoming more innovative (Garcia *et al*, 2009). Of course the lack of information is the factor, which is hampering the innovation activities among the companies.

13. Resources – can be tangible or intangible. These resources can include time, which is spend on innovation activities, number of employees, dedicated to this activity, amount of investment, which is needed for equipment and etc. Tangible and intangible resources are equally important for the company, which is implementing innovation.

14. Culture of organization also plays important role in company's innovation activity. According to Valancia *et al* (2010), organizational culture is considered to be one of the key elements in both enhancing and inhibiting innovation. A culture supporting higher-level learning would be rooted in the values of creativity, innovation, expertise, self-

development, knowledge sharing, mutual trust and appreciation of diversity (Zdunczyk and Blenkinsopp, 2007). Yng Lyng (2003) noted that companies should create a “no-blame” culture to encourage staff to experiment with the new ideas. According to Blayse and Manley (2004), company should not penalize new ways of working if they do not succeed; a “culture of collaboration”, in which people is able to question ways of working without fear of penalty if they are unsuccessful; shared perception that participants are all striving to achieve a greater understanding of each other’s goals. If the right type of norms exists, then there will be a great tendency on the part of the organization to promote innovation and technological change. If on the other hand the wrong culture prevails, no matter how well the intention of people trying to promote entrepreneurial behavior, success will not be achieved (Benmansour and Hogg (2002). A result of organizational cultures being unreceptive to innovation is the risk of failure to seize new approaches to pursuing market opportunities (Garcia *et al*, 2009).

According to Hardie (2010), “everyone for himself” attitude is a major impediment to a more co-operative industry culture and a more innovative industry. Trust that an individual can expect fair treatment from an employer is a prerequisite for an industry culture where new ideas widely generated and readily shared.

The good practice is established in “Virgin” company. “Virgin” is a company that has done an exceptional job of creating an environment where employees feel that not only it is acceptable to innovate, it is expected of them (Loewe and Dominiquini, 2006). Google is another example in this respect. It reinforces the importance of innovation by letting employees spend 20 percent of their time working on their own ideas and keeping several active e-mail lists to collect ideas from all employees.

15. The role of Leadership. This is totally an internal factor. The leadership task is to harness economic and social trends, capture the tremendous amount of knowledge and experience that exists in networks worldwide and combine these in ways that command respect, generate enterprise and create value (Dearing, 2000). Business leaders are directly responsible for the competitive success of companies and, therefore, for inspiring, fostering and protecting the creative initiatives of the employees (Pellicer *et al*, 2010). Leaders usually are the initiators of innovation activity in the company. They are very creative, experienced and qualified persons, who are not afraid to take a huge risk and try to implement things as a result to earn bigger profit, to become more attractive for customers, or just to be exclusive. As it was mentioned before, leaders characteristics are important for “Business angels” (the one from funding sources) in assessing the company’s capacity.

According to Bossink (2004), the technological competence is a prerequisite for effective leadership and effective leadership is essential for technological innovation in construction.

As per Blayse and Manley (2004), the attributes of leaderships (or “champions”), need to include possession, at the very least, of power and technical competence. This is because high levels of technical competence enable champions to overcome the uncertainty of construction innovation, and their authority enables to challenge resistance to innovation.

16. Technological opportunity. According to Zakic *et al* (2008), technological development can lead companies to radical and disruptive innovations. Technological opportunities are very interesting for entrepreneurs, business circles and innovation researches. Investment in new technologies can bring very high return. Of course, new technologies are more expensive than already existing technologies – companies have to decide if they are able to invest in such kind of innovation and to take all risk if this new technology will not be working as it was expected.

Bossink (2004) has noted that technological capabilities of organizations in the industry push the implementation of the new solutions by these organizations in their construction projects. According to Wziatek-Kubiak *et al* (2010), firms in low and medium low technology industries are less likely to face impediments to innovation than those in high and medium high technology industries.

Comparing with other economical sectors, construction sector are not very likely to invest in technological innovations, as it does information and communication companies. Construction companies are more organizational and marketing innovators, than technological innovators.

Table 1. Innovative enterprises by kind of innovation and economic activity, 2008–2010

NACE 2 code	Technological innovators	Of which				Only organizational and/or marketing innovators	Economic activity
		Only product	Only process	Both product and process	innovation activities ongoing or discontinued at the end of 2010		
	20,3	4,4	5,4	8,3	2,2	12,2	Total
B	12,0	-	4,0	8,0	-	14,0	<i>Mining and quarrying</i>
C	22,2	7,2	5,5	7,5	2,0	9,8	<i>Manufacturing</i>
D	26,2	2,4	21,4	2,4	-	8,3	<i>Electricity, gas, steam and air conditioning supply</i>
E	40,0	1,0	23,6	11,8	3,6	5,5	<i>Water supply, sewerage,</i>

							<i>waste management and remediation activities</i>
F	9,8	1,5	2,8	2,2	3,3	12,8	Construction
G46	18,7	4,3	7,2	6,0	1,2	20,3	<i>Wholesale trade</i>
H	16,0	0,6	2,3	12,7	0,4	9,3	<i>Transport and storage</i>
I	49,6	12,0	8,5	24,1	5,0	12,8	<i>Information and communication</i>
K	40,5	5,2	2,6	29,3	3,4	12,9	<i>Financial and insurance activities</i>
M	29,3	5,6	8,4	11,8	3,5	16,0	<i>Professional, scientific and technical activities</i>

Source: Lithuanian Department of Statistic.

17. Industry relationships and cooperation. An important tool to improve the firm's knowledge base and therefore its innovativeness is to enter cooperation with partners like other companies and/or universities and specialized research institutions at home or abroad (Tiwari and Buse, 2007). The information flows between these economic objects can circulate and in formal and in informal networks, and they can strengthen or weaken the results of innovation activity. Bossink (2004) stated that long-term relations between firms and external knowledge centers facilitated access to, and adoption of, new technologies in the constructions management. He also underpinned the importance of the creation, stabilization and upgrading of knowledge networks consisting of universities, research institutes, and knowledge-intensive business service. Exchange of knowledge facilitates the development of new knowledge that can be used to innovate. According to BERR (2008), there is very important that fair commercial procedures will be based on trust, e.g. collaborative agreements, and no unfair contracts, also use of project insurance. Early involvement of all key players in the project, enabling optimum solutions to be identified to specific issues. Second tier contractors are an important source of innovation and need to be fully integrated. According to Bosch-Sijtsema and Postma (2009), the firms should perceive benefits in cooperating (financial benefits, increase in skills and market, spreading of risks and costs).

The Figure (8) presents Lithuania's situation. Mostly companies cooperate with suppliers of equipment, materials, components or software. This is the 42.6 percent of all cooperation partners. This is high number, because such form of cooperation is natural, inevitable and daily process to all companies, which are having any activity. Other enterprises within the enterprise group are on the second place. Usually these companies operate together, buy products or services from each other, and generate money flows. The practice shows, that if parent company implement any kind of innovation, the same innovation attempts to implement and subsidiary company. Cooperation between enterprises helps to

save money, for example, on researches, because these companies can share results carried out from research, and act together. The weakest part of cooperation is with universities or other higher education institutions (only 3.5 percent) and government or public research institutes (3.9 percent).

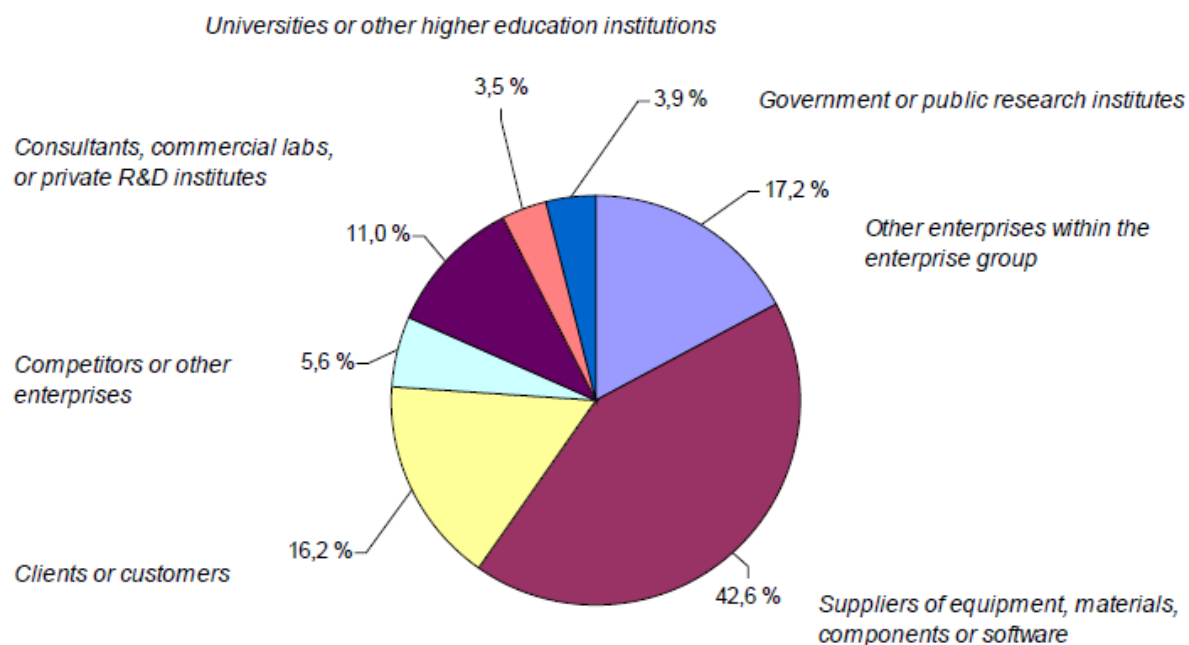


Figure 8. Cooperation partners in innovation activities by importance, 2008–2010
Source: Lithuanian Department of Statistics.

18. **Origin of ownership.** According to Zakic *et al* (2008), there are little empirical evidence about the influence origin of ownership (domestic/foreign) on the product and process innovation. Multinational companies should play the leading role in process innovation in comparison with domestic companies, in regard to technological and organizational capabilities. Sharing knowledge among the company, wide information about other, international, market has positive value to development of innovation activity.

19. **Features of product/service.** The each product or service has different features, which are common in the certain sector. According to Harty (2005), construction has some particular characteristics based on long-standing ways of working, and which together make it unique from other areas of industry. Hardie (2010) noted that construction industry is made up of many interconnecting elements, complicated hierarchies and a high degree of user involvement in the overall process. In this sense, construction is not directly comparable to any other industry although it has features in common with several other project-based industries. Unlike some other project-based endeavors, such as, for example, the movie

industry, the construction industry produces artifacts which are very long lived and continue to impact on the environment and society for many years after their production. According to Barrett and Sexton (2006) the project-based nature of the construction industry is a significant barrier to innovation. The temporary nature of the project teams and the short-term relationships between organizations makes the transfer of innovations from project to project and firm to firm extremely difficult.

20. Innovation strategy. Before implementing the new innovation into the organization processes, it is necessary to determine that kind of innovation form to choose, to evaluate available resources (including time, money, human resources), to ensure that knowledge, which has organization, are sufficient, to evaluate opportunities of get funding/support, and to foresee the potential risk. All these indicators can be considered as part of innovation strategy. It is very important to choose the right innovation strategy. According to Blayse and Manley (2004), effective innovation performance at firm level requires combining elements into a formal innovation strategy. The final form of the strategy will be a function of the quantity and quality of organizational capabilities.

To summarize this chapter, the all factors, indicated according to regional and international literature review, are placed into the below table.

Table 2. Factors, impacting innovation activity – summarizing review of literature sources (made by author)

No.	Factors	Authors
1	Clients	Keršys (2008), Zakic <i>et al</i> (2008), Zawdie <i>et al</i> (2012), Blayse and Manley (2004), Nečadova and Scholleova (2011), Hartmann (2006).
2	Manufacturers	Keršys (2008), Blayse and Manley (2004), Bossink (2004).
3	High cost	Demirbas <i>et al</i> (2011), Garcia <i>et al</i> (2009), Baležentis (2007), Nečadova and Scholleova (2011).
4	Incorrect measures	Benmansour and Hogg (2002), Ramanauskienė (2010), IBM (2006), Andrews (2005).
5	Competition	Keršys (2008), Zakic <i>et al</i> (2008), Zawdie <i>et al</i> (2012), Garcia <i>et al</i> (2009), Baležentis (2007), Blockley and McDowell (2010), Wziatek-Kubiak <i>et al</i> (2010).
6	Risk	Mostafa (2005), Hardie (2010), Juknienė Ž. (2006), Janger and Holzl (2011), Keršys (2008), Benmansour and Hogg (2002), Zawdie <i>et al</i> (2012), Johnson (2010), IBM (2006), Andrews (2005).
7	Demand	Johannessen (1994), Keršys (2008), Zakic <i>et al</i> (2008), Blockley and McDowell (2010).
8	Company size	Heimonen (2012), Demirbas <i>et al</i> (2011), Janger and Holzl (2011), Zakic <i>et al</i> (2008), Johnson (2010), Molero (2009), Wziatek-Kubiak <i>et al</i> (2010).
9	Funding sources	Hardie (2010), Heimonen (2012), Demirbas <i>et al</i> (2011), Janger and Holzl (2011), Keršys (2008), Benmansour and Hogg (2002), Zakic <i>et al</i> (2008), Ramanauskienė (2010), Tiwari and Buse (2007), Molero (2009), Ozmen and Saatcioglu (2010), Andrews (2005).
10	Regulation/standards	Hardie (2010), Demirbas <i>et al</i> (2011), Benmansour and Hogg (2002), Benmansour and Hogg (2002), Blayse and Manley (2004), BERR (2008),

		Pellicer, Yepes and Rojas (2010), Blockley and McDowell (2010).
11	Staff	Hardie (2010), Loewe and Dominiquini (2006), Demirbas <i>et al</i> (2011), Janger and Holzl (2011), Keršys (2008), Garcia <i>et al</i> (2009), Tiwari and Buse (2007), Bossink (2004), Baležentis (2007), Nečadova and Scholleova (2011).
12	Information and knowledge	Hardie (2010), Janger and Holzl (2011), Keršys (2008), Ramanauskienė (2010), Zawdie <i>et al</i> (2012), Johnson (2010), Garcia <i>et al</i> (2009), Molero (2009), Bossink (2004), Pellicer, Yepes and Rojas (2010), Nečadova and Scholleova (2011).
13	Resources	Janger and Holzl (2011), Keršys (2008), Ramanauskienė (2010), Blayse and Manley (2004), Nečadova and Scholleova (2011).
14	Culture of organization	Mostafa (2005), Hardie (2010), Olaisen, and Johannessen (1993), Johannessen (1994), Loewe and Dominiquini (2006), Demirbas <i>et al</i> (2011), Benmansour and Hogg (2002), Ramanauskienė (2010), Zawdie <i>et al</i> (2012), Blayse and Manley (2004), Garcia <i>et al</i> (2009), Valencia <i>et al</i> (2010), Zdunczyk and Blenkinsopp (2007), Hartmann (2006).
15	The role of leadership	Johannessen (1994), Loewe and Dominiquini (2006), Demirbas <i>et al</i> (2011), Dearing (2000), Blayse and Manley (2004), Bossink (2004).
16	Technological opportunities	Demirbas <i>et al</i> (2011), Keršys (2008), Zakic <i>et al</i> (2008), Zawdie <i>et al</i> (2012), Bossink (2004), Wziatek-Kubiak <i>et al</i> (2010), Nečadova and Scholleova (2011).
17	Industry relationships and cooperation	Janger and Holzl (2011), Keršys (2008), Blayse and Manley (2004), Blayse and Manley (2004), Tiwari and Buse (2007), BERR (2008), Bossink (2004), Pellicer, Yepes and Rojas (2010), Bosch-Sijtsema and Postma (2009).
18	Origin of ownership	Zakic <i>et al</i> (2008).
19	Features of product/service	Hardie (2010), Harty (2005), Barrett P., Sexton M. (2006), Blayse and Manley (2004).
20	Innovation strategy	Blayse and Manley (2004), Keršys (2008), Zawdie <i>et al</i> (2012), Hartmann (2006).

The above Table (2) shows, that one of the most popular factor among the literature authors is “Culture of organization”. Culture of organization is more popular and more valued in foreign countries than is Lithuania. The creativity of employees is constantly encouraged. The least by importance factor is “Origin of ownership”- only one author has identified it as factor, which may impact product or service innovation development.

3. THE RESEARCH OF FACTORS IN CONSTRUCTION SECTOR

3.1. The review of construction sector

The construction sector was chosen to be analyzed because this is one of the most important sectors in modern economies. Also, this sector is the less innovative, comparing with other sectors.

The construction companies were dominated among the whole sectors, but the last economic crisis has changed their position. In the beginning of 2008 construction sector has started to experience the reduction of construction works and stagnation. The below Figure (9) best describe changes in construction sector. In 2011 construction sector has reached the level of 2005 – the old and not finished projects were renewed and construction companies started to implement new projects.

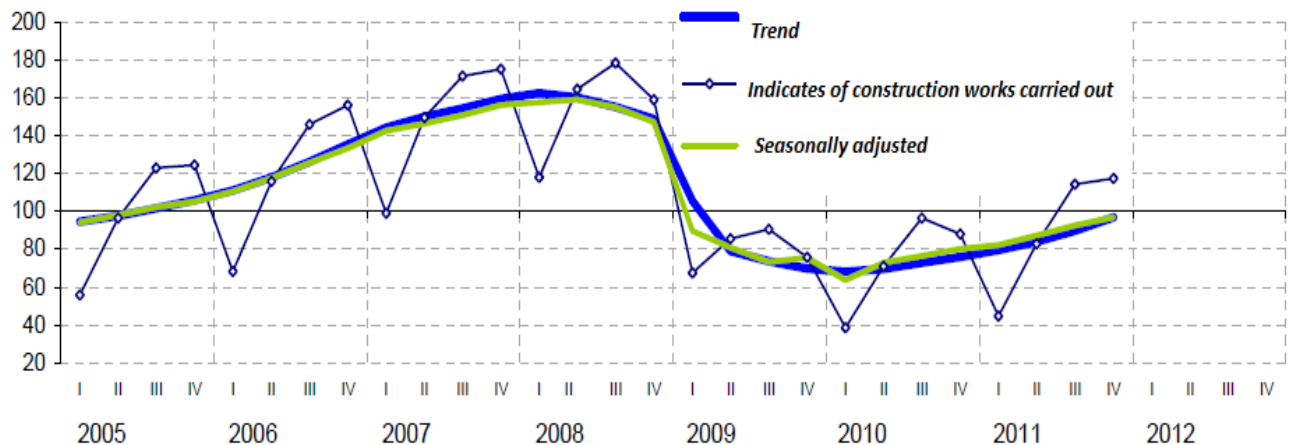


Figure 9. Indices of construction work carried out

Source: Economic and Social Development in Lithuania, 2012. Lithuanian Department of Statistics.

The construction sector is not very innovative, comparing with other sectors in Lithuania. The majority of construction firms do not participate in innovation activities. The below Figure (10) shows, that manufacturing takes a leading position among all innovative companies (almost 46 percent). It means that almost a half of all manufacturing companies are tending to innovate. Construction companies took only 7.1 percent.

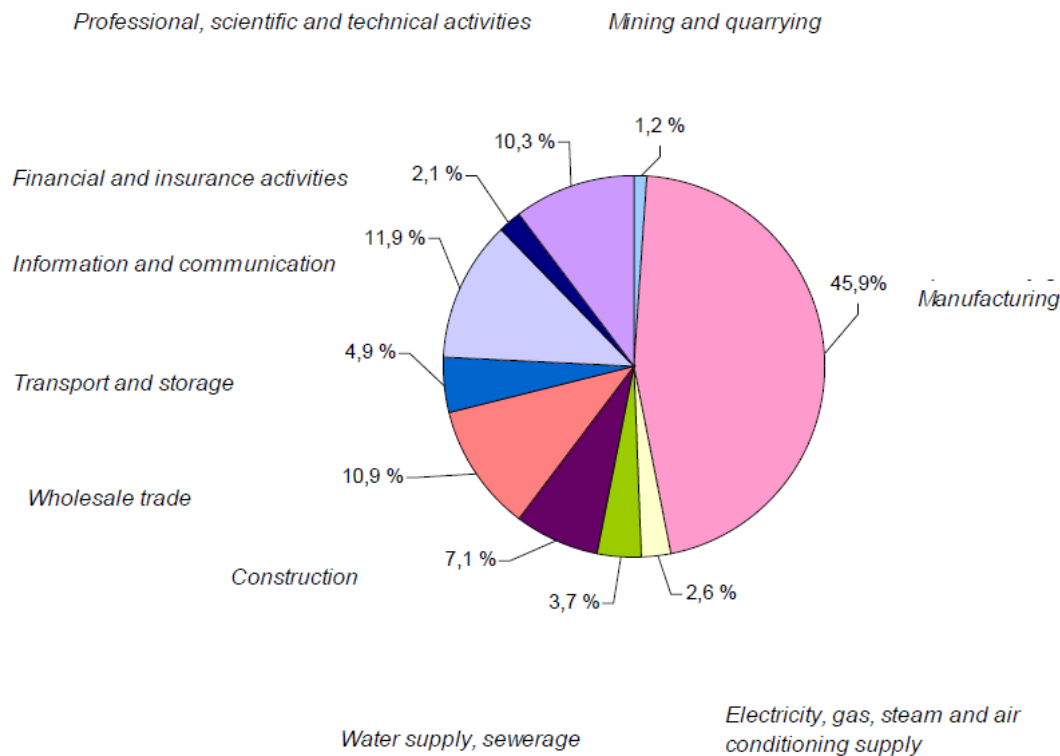


Figure 10. Survey sample by economic activity, 2008–2010

Source: Lithuanian Department of Statistics.

Table 3. Innovative enterprises, percent of all enterprises

NACE 2 code	Innovative enterprises				Economic activity
	2002-2004	2004-2006	2006-2008	2008-2010	
	33,5	34,8	28,8	32,5	Total
B	40,4	28,9	32,6	26,0	Mining and quarrying
C	40,4	40,0	30,2	32,0	Manufacturing
D	49,4	40,0	56,6	34,5	Electricity, gas, steam and air conditioning supply
E	26,8	37,6	34,0	45,5	Water supply, sewerage, waste management and remediation activities
F	26,2	33,5	17,3	22,6	Construction
G46	30,9	28,8	29,9	39,0	Wholesale trade
H	22,3	29,3	22,3	25,3	Transport and storage
I	32,0	27,8	47,4	62,4	Information and communication
K	69,1	67,7	51,4	53,4	Financial and insurance activities
M	39,2	49,2	38,0	45,3	Professional, scientific and technical activities

Source: Lithuanian Department of Statistics.

The above Table (3) shows, that only 22.6 percent of all construction companies are innovative. This number is the lowest from all economic activity. The information and

communication sector is the biggest innovator – this is more than a half of all companies in this sector. This situation is not sufficient and should be changed.

3.2. Research Methodology

There are considered 20 key factors, which may impact innovation activity in construction sector. These factors were identified by literature review. All these factors are different – it is hard to decide which of these factors is more important and does more impact to innovation activity, and which is less important. In order to determine their importance, the multiple criteria decision making method was chosen.

There are a lot of methods proposed to use in literature. The most popular methods are SAW, TOPSIS and COPRAS.

SAW (*Simple additive weighting*) – is the oldest, most widely known and practically used method for aggregating several criteria (MacCrimmon, 1968). The method involves adding together criteria values for each alternative and applying weight to individual criteria. Criteria must be maintained using the same scale for this to be possible. Once values for all alternatives have been aggregated, the alternative with the highest (or lowest) value is then selected as the comparatively optimal solution (Zavadskas *et al*, 2010). SAW may be used if all the criteria are maximizing and it is recommended to use formula for transforming minimizing criteria. Another SAW limitation is the requirement that all criteria values should be positive. In the opposite cases negative values are transformed to positive values (Podvezko, 2011).

TOPSIS (*Technique for order preference by similarity to an ideal solution*) – is based on the idea, that the chosen alternative should have the shortest distance from the positive ideal solution and on the other side the farthest distance of the negative ideal solution (Jahanshahloo *et al*, 2006).

COPRAS (*A Method of Multiple Criteria Complex Proportional Evaluation*) - this method assumes direct and proportional dependence of significance and priority of investigated alternatives on a system of attributes. The significance (efficiency) of comparative alternatives is determined on the basis of describing positive (“pluses”) and negative (“minuses”) characteristics. This method presents a possibility to coordinate different objectives and to determine their priorities. This method makes it possible to compare the alternatives evaluating the superiority of one alternative over another. The first time this method was described in 1996, by Zavadskas and Kaklauskas in their work “Multiple criteria evaluation of buildings” (Zavadskas *et al*, 2010). Vilutienė *et al* (2009),

Zavadskas *et al* (2010), Andruškevičius (2005), Drejeris and Bivainis (2009), Turskis *et al* (2012), Kildienė *et al* (2011), Banaitis *et al* (2007) and others successfully applied this method for solving different multi objective problems.

For this research was chosen multiple criteria decision making method COPRAS.

In order to evaluate factors and alternatives correctly, it is important to perform specific multiple criteria analysis stages:

- To perform a survey for experts, that will be the basis for further calculations;
- On the basis of survey results to perform evaluation of criteria system and to settle the rankings and weights (importance) of the each factor;
- To perform the evaluation alternatives and to settle the rates according factors system;
- According to settled weights and alternatives evaluation results to perform calculations, determine the best value and identify the best alternative.

The **main purpose** of this research is to identify factors, which are most impacting innovation activity in construction sector. Alternatives will be given for experts to evaluate not just for reason to select the best alternative, but and discover how every factor affects it and that are their importance in different situations.

3.3. Research

The main factors where indicated during the literature review. These factors are presented in the Table (4).

First of all, the importance of the each factor is determined. For this purpose is completed the questionnaire (Table 4 and Annex A). The questionnaire should be completed by 5 to 10 experts, in this situation – experts, working into the construction sector and having more than 3 years experience in this sector.

As a survey respondents and experts of multiple criteria analysis 10 construction sector professionals, working in six different construction companies were chosen. Survey respondents have negotiation experience from 3 to more than 10 years in construction companies. Working before and now in innovative and non-innovative construction companies have formed for expert strong opinion and clear understanding about factors, which may impact innovation activity among the construction companies. Experts are named as E1, E2, ... E10.

Two part survey was given to the experts. The first part of the survey is set to determine the ranking and weights (importance) of the factors. The second part of the survey

is devoted to evaluate three innovation types in the framework of factor system. A survey form is attached as Appendix A.

The results of the survey are presented below.

3.3.1. Evaluation of criteria

In the first part of survey respondents were asked to rank factors and to attribute a weight (importance) of the factors. The each factor is rated from 1 to 100 score. Factor, which has more impact to innovation activity in construction sector, is rated at a higher score.

Table 4. Evaluation of the factors (made by author)

No.	Factor	Evaluation
1	Clients	
2	Manufacturers	
3	High cost	
4	Incorrect measures	
5	Competition	
6	Risk	
7	Demand	
8	Company size	
9	Funding sources	
10	Regulation/standards	
11	Staff	
12	Information and knowledge	
13	Resources	
14	Culture of organization	
15	The role of leadership	
16	Technological opportunities	
17	Industry relationships and cooperation	
18	Origin of ownership	
19	Features of product/service	
20	Innovation strategy	

After questionnaires are completed, all data should be entered in the Table (5), in case to calculate rank and weight of each evaluated factor.

Table 5. Ranking of the factors sample

No.	Factors	E_1	E_2	...	E_n	Rank	ΔS_i	ΔS_i^2	Weight
1									
2									
...	...								
19									
20									

Calculation of evaluation sum for each factor:

$$S_i = \sum_{j=1}^n b_{ij}, \quad j = \overline{1, n}, \quad (1)$$

where b_{ij} – the value of the i factor evaluated by j expert;

S_i – the sum of all i factor evaluation of all j experts;

n – the number of all experts;

ΔS_i^2 - deviation from the average.

The average (S^*) can be calculated by the following formula:

$$S^* = \frac{\sum_{i=1}^m S_i}{m}, \quad i = \overline{1, m}, \quad (2)$$

where S_i – the sum of all i factor evaluation;

m – the number of all factors.

Then deviation from the average (ΔS_i^2) can be calculated by the formula:

$$\Delta S_i = S_i - S^* \quad (3)$$

The weight of the factor is calculated by the following formula:

$$q_j = \frac{S_i}{\sum_{i=1}^m S_i} \quad (4)$$

The survey data is entered in the Table (6).

Table 6. The data of expert survey (made by author)

No.	Factor	Expert										Average, S^*
		E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	
1	Clients	70	90	100	80	100	80	100	100	50	90	86,00
2	Manufacturers	60	50	80	90	80	90	95	90	80	95	81,00
3	High cost	80	80	90	100	75	30	80	80	60	95	77,00
4	Incorrect measures	50	60	100	70	50	70	80	90	30	85	68,50
5	Competition	70	70	90	100	85	100	95	70	100	100	88,00
6	Risk	30	40	80	90	75	70	80	70	40	100	67,50
7	Demand	60	90	100	70	90	90	85	100	70	90	84,50
8	Company size	40	10	50	60	85	100	90	80	80	30	62,50
9	Funding sources	60	30	70	80	55	90	85	100	90	100	76,00

10	Regulation/standards	30	20	50	70	65	30	85	100	75	90	61,50
11	Staff	60	50	100	80	85	80	75	100	50	60	74,00
12	Information and knowledge	60	50	100	90	100	100	85	100	60	90	83,50
13	Resources	70	60	100	100	90	100	90	90	100	100	90,00
14	Culture of organization	80	60	100	65	80	90	80	80	50	60	74,50
15	The role of leadership	90	80	100	70	85	90	85	70	80	80	83,00
16	Technological opportunities	80	30	70	80	75	60	85	100	100	100	78,00
17	Industry relationships and cooperation	50	50	80	100	75	80	80	90	80	90	77,50
18	Origin of ownership	70	20	70	50	80	40	100	70	50	10	56,00
19	Features of product/service	80	90	80	65	70	100	80	90	90	80	82,50
20	Innovation strategy	80	50	100	50	85	100	100	100	85	90	84,00

After this, further calculations are completed and Table (7) is filled with the data.

Table 7. Ranking of the factors (made by author)

No.	Factor	S_i	Rank	ΔS_i	ΔS_i^2	Weight
1	Clients	860	3	774,0	599076,0	0,0562
2	Manufacturers	810	9	729,0	531441,0	0,0529
3	High cost	770	12	693,0	480249,0	0,0503
4	Incorrect measures	685	16	616,5	380072,3	0,0448
5	Competition	880	2	792,00	627264,0	0,0573
6	Risk	675	17	607,5	369056,3	0,0441
7	Demand	845	4	760,5	578360,3	0,0552
8	Company size	625	18	562,5	316406,3	0,0408
9	Funding sources	760	13	684,0	467856,0	0,0497
10	Regulation/standards	615	19	553,5	306362,3	0,0402
11	Staff	740	15	666,0	443556,0	0,0484
12	Information and knowledge	835	6	751,5	564752,3	0,0546
13	Resources	900	1	810,0	656100,0	0,0588
14	Culture of organization	745	14	670,5	449570,3	0,0487
15	The role of leadership	830	7	747,0	558009,0	0,0540
16	Technological opportunities	780	10	702,0	492804,0	0,0510
17	Industry relationships and cooperation	775	11	697,5	486506,3	0,0506
18	Origin of ownership	560	20	504,0	254016,0	0,0366
19	Features of product/service	825	8	742,5	551306,3	0,0537
20	Innovation strategy	840	5	756,0	571536,0	0,0549

$$\sum S_i = 15302;$$

$$\sum q_i = 1.0$$

1. The sum of the each evaluated factor is calculated by the (1) formula:

$$S_1 = 70 + 90 + 100 + 80 + 100 + 80 + 100 + 100 + 50 + 90 = 860$$

$$S_2 = 60 + 50 + 80 + 90 + 80 + 90 + 95 + 90 + 80 + 95 = 810$$

.....

$$S_{20} = 80 + 50 + 100 + 50 + 85 + 100 + 100 + 100 + 85 + 90 = 840$$

2. The average of each evaluated factors can be calculated by the (2) formula:

$$S_1^* = \frac{70 + 90 + 100 + 80 + 100 + 80 + 100 + 100 + 50 + 90}{10} = 86.00$$

$$S_2^* = \frac{60 + 50 + 80 + 90 + 80 + 90 + 95 + 90 + 80 + 95}{10} = 81.00$$

.....

$$S_{20}^* = \frac{80 + 50 + 100 + 50 + 85 + 100 + 100 + 100 + 85 + 90}{10} = 84.00$$

3. Then deviation from the average (ΔS_i) can be calculated by the (3) formula:

$$\Delta S_1 = 860 - 86 = 774$$

$$\Delta S_2 = 810 - 81 = 729$$

.....

$$\Delta S_{20} = 840 - 84 = 756$$

4. The weight of the rated factors calculated by the (4) formula:

$$\sum S_i = 15302$$

$$q_1 = \frac{860}{15302} = 0.0562$$

$$q_2 = \frac{810}{15302} = 0.0529$$

.....

$$q_{20} = \frac{840}{15302} = 0.0549$$

5. When using a multiple criteria method and experts' opinions, it is very important to check the compatibility of their views. When there are more than 2 experts, their opinions' compatibility is checked by concordance coefficient (Baležentis and Žalimaitė, 2011).

- a. Firstly, there is counted the average of the ranking values:

$$a = 0,5n(m + 1) \quad (5)$$

where n – number of experts;

m – number of factors.

b. The sum of deviation square from average is counted by the formula:

$$S^2 = \sum_{i=1}^m \left(\sum_{j=1}^n b_{ij} - a \right)^2 \quad (6)$$

c. Finally, the concordance coefficient is counted by the following formula:

$$W = \frac{12S^2}{n^2(m^3 - m)}; \quad (7)$$

where W – concordance coefficient.

In case the concordance coefficient is calculated in the ten-point system, the S_i should be divided by 10.

Table 8. Counted deviation square from average (made by author)

No.	Factor	$S_i/10$	Average, a	Deviation square from average, S^2
1	Clients	86,0	105	570025
2	Manufacturers	81,0	105	497025
3	High cost	77,0	105	442225
4	Incorrect measures	68,5	105	336400
5	Competition	88,0	105	600625
6	Risk	67,5	105	324900
7	Demand	84,5	105	547600
8	Company size	62,5	105	270400
9	Funding sources	76,0	105	429025
10	Regulation/standards	61,5	105	260100
11	Staff	74,0	105	403225
12	Information and knowledge	83,5	105	532900
13	Resources	90,0	105	632025
14	Culture of organization	74,5	105	409600
15	The role of leadership	83,0	105	525625
16	Technological opportunities	78,0	105	455625
17	Industry relationships and cooperation	77,5	105	448900
18	Origin of ownership	56,0	105	207025
19	Features of product/service	82,5	105	518400
20	Innovation strategy	84,0	105	540225

The sum of deviation square from average is: $S^2 = 17,604.25$

$$W = \frac{12 * 17,604.25}{10^2 (20^3 - 20)} = 0.2647$$

Hypotheses are formulated: H_0 – experts' evaluation are contradictory ($W=0$); H_1 – experts' evaluation are similar ($W>0$). If calculated χ_f^2 is bigger than critical value $\chi^2(0,05;m-1)$ (Griniuvienė(2001), the zero hypotheses is rejected.

$$\chi_f^2 = W * n * (m - 1) \quad (8)$$

$$\chi_f^2 = 50,29 > \chi^2(0,05;19) = 30,10 \quad (9)$$

This value shows that experts' opinions are compatible and the calculations can be continued.

As Table (7) shows, the ranking of factors after survey are:

1. Resources;
2. Competition;
3. Clients;
4. Demand;
5. Innovation strategy;
6. Information and knowledge;
7. The role of leadership;
8. Features of product/service;
9. Manufacturers;
10. Technological opportunities;
11. Industry relationships and cooperation;
12. High cost;
13. Funding sources
14. Culture of organization;
15. Staff;
16. Incorrect measures;
17. Risk;
18. Company size;
19. Regulation/standards;
20. Origin of ownership.

Factors ranking showed, that most important is resources. During the literature analysis, many of foreign authors identified another factors – culture of organization – as one of the most important factor. It can be noted, that foreign countries pay more attention to creativity among the company, sharing of the information, knowledge and experience between each other, nor do the Lithuanians, especially construction companies. This can only confirm that Lithuania's companies have established other priorities.

3.3.2. Evaluation of three innovation types

The second part of the survey was devoted to evaluate three innovation types in the framework of factor system. Experts were asked to evaluate each of the innovation type (mark 1-100, where 100 – the biggest impact, 1 – the least impact), using the system of factors, formed before.

At it was mentioned before – in the literature review – there may be three types of innovations:

1. Sustained innovation;
2. Breakout innovation;
3. Disruptive (radical) innovation.

The particular alternatives of each innovation type were given for experts to evaluate the importance of every factor in different kind of projects. After this evaluation, calculation will be performed and it will become clear, that kind of innovation type should be the best to adapt.

In this case study, three construction projects were chosen to evaluate.

Alternative 1. Sustained innovation. As an alternative were given the simple building renovation project. It is counted, that after renovation, the flat value increases about 30 percent. Renovation improves the external design of the building, living conditions, helps to save cost on heating. It is cheaper to renovate the building than to demolish it and build new one. Renovation is very important issue in nowadays – there are a lot of old constructions building, which are necessary to renew, however no such extent of the renovation, which is expected to. The problems may be, that people are not interested to implement something new, in case to increase their living conditions, limited information, incorrect measure of the renovation benefits, people do not want to invest money, because they are not planning to live in this house forever, widespread distrust of government and its' funding mechanism.



Figure 11. Building before and after renovation.

Source: Atnaujink būstą, 2010-2012.

Alternative 2. Breakout innovation. As an example were given the building renovation project, with passive house components.

Passive houses consume less than quarter of the energy required for a standard building. They have no separate heating systems apart from heat recovery ventilation. The efficiency is based on well-insulated and air-tight passive building envelope solutions.

The renovation according to passive house standards is popular and widely used in foreign countries. This kind of renovation is more expensive, comparing with simple house renovation, but it has bigger benefits and better performance - the heat loss of a passive house is so small that a normal heat distribution system will be unnecessary. Passive houses use inexhaustible energy sources, such as solar energy.



Figure 12. Building before and after renovation.

Source: Renovation up to passive house standard (2007)

Alternative 3. Disruptive (radical) innovation. As an example were given the construction project of a new residential building, according to the passive house standards.

This practice is widely spread among the EU countries. Lithuania has built only individual passive house. This alternative suggests building the first residential building in

Lithuania, according to passive house standards. One of the well known construction company has already planed to build such house in Lithuania.

This project has high risk, because this will be the first one in the market, counting about the materials, possible buyers, market trends should be done very accurately.



Figure 13. Passive house.

Source: Czech Green Building Council, 2012.

Not all of factors in this situation could be evaluated by experts. One of factors “Innovation strategy” cannot be evaluated by experts, because they are evaluating innovation types (strategies). This factor is important as a factor, impacting innovation activity in construction sector, because incorrect chosen strategy can lead to failure of innovation process. As this factor is too important to be excluded, in this case it was assumed that this factor has similar impact to all three innovation strategies. For the calculations this factor gets rating of 50.

The results of 1st innovation type calculations are presented in Table (9), 2nd innovation type – Table (10), 3rd innovation type – Table (11).

Table 9. Evaluation of sustained innovation (made by author)

No.	Factor	Expert										Average, S_1^*
		E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	
1	Clients	80	100	75	80	70	65	75	85	80	70	78,00
2	Manufacturers	70	80	60	65	90	80	70	90	85	65	75,50
3	High cost	60	70	80	70	75	60	50	80	75	80	70,00
4	Incorrect measures	70	60	50	80	40	50	70	65	75	60	62,00
5	Competition	90	100	95	80	85	90	90	100	100	95	92,50
6	Risk	60	50	40	70	80	60	65	70	70	80	64,50
7	Demand	80	70	80	85	90	100	70	60	80	85	80,00

8	Company size	70	60	50	60	60	55	65	70	70	80	64,00
9	Funding sources	80	80	75	60	100	80	70	75	70	65	75,50
10	Regulation/standards	90	80	100	85	75	60	70	60	80	70	77,00
11	Staff	100	90	70	70	80	85	80	75	75	80	80,50
12	Information and knowledge	90	60	90	70	85	80	60	70	70	85	76,00
13	Resources	70	80	75	70	80	60	90	100	80	75	78,00
14	Culture of organization	60	50	75	60	80	70	65	70	70	60	66,00
15	The role of leadership	50	60	65	85	90	75	80	70	80	50	70,50
16	Technological opportunities	60	90	70	100	85	90	100	70	90	100	85,50
17	Industry relationships and cooperation	60	75	80	90	80	90	85	70	100	90	82,00
18	Origin of ownership	20	10	30	50	60	50	40	30	45	50	38,50
19	Features of product/service	75	60	70	80	75	90	85	60	85	65	74,50
20	Innovation strategy	50	50	50	50	50	50	50	50	50	50	50,00

$$\sum S_1^* = 1,440.50$$

Table 10. Evaluation of breakout innovation (made by author)

No.	Factor	Expert										Average, S_2^*
		E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	
1	Clients	100	90	80	85	70	90	100	95	80	70	86,00
2	Manufacturers	90	85	90	75	80	95	100	90	85	90	88,00
3	High cost	90	80	85	90	90	95	90	100	100	95	91,50
4	Incorrect measures	85	80	70	85	100	80	80	95	90	100	86,50
5	Competition	90	80	90	100	95	80	85	70	85	75	85,00
6	Risk	85	90	100	85	90	100	95	80	75	90	89,00
7	Demand	90	100	90	80	95	90	80	100	70	75	87,00
8	Company size	60	50	70	80	70	85	90	90	85	80	76,00
9	Funding sources	90	90	80	90	100	100	95	80	80	90	89,50
10	Regulation/standards	90	90	100	100	90	90	100	85	100	90	93,50
11	Staff	80	85	65	80	70	75	80	95	80	80	79,00
12	Information and knowledge	100	90	100	90	95	80	95	90	100	100	94,00
13	Resources	90	100	90	95	80	85	100	100	90	85	91,50
14	Culture of organization	70	70	50	60	75	65	80	75	70	90	70,50
15	The role of leadership	70	80	70	75	80	70	75	75	80	60	73,50
16	Technological opportunities	90	100	100	90	95	85	90	100	95	85	93,00
17	Industry relationships and cooperation	80	90	70	75	70	80	90	95	100	90	84,00
18	Origin of ownership	50	40	50	30	50	55	60	55	45	30	46,50
19	Features of product/service	85	90	100	80	90	75	70	80	85	90	84,50
20	Innovation strategy	50	50	50	50	50	50	50	50	50	50	50,00

$$\sum S_2^* = 1,638.50$$

Table 11. Evaluation of disruptive innovation (made by author).

No.	Factor	Expert										Average, S_3^*
		E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	
1	Clients	100	90	100	95	90	100	100	100	95	90	96,00
2	Manufacturers	90	80	70	95	90	100	90	80	85	70	85,00
3	High cost	100	100	90	90	100	95	95	100	100	95	96,50
4	Incorrect measures	90	80	100	80	70	60	75	80	70	60	76,50
5	Competition	70	60	50	60	75	60	50	40	70	75	61,00
6	Risk	100	90	90	80	70	100	95	85	100	80	89,00
7	Demand	80	100	100	100	90	95	90	100	90	80	92,50
8	Company size	60	70	80	85	80	70	75	80	90	95	78,50
9	Funding sources	90	100	95	90	100	95	100	100	90	95	95,50
10	Regulation/standards	85	80	70	85	80	90	95	100	85	80	85,00
11	Staff	90	80	85	80	75	75	80	90	90	85	83,00
12	Information and knowledge	100	100	100	100	90	100	95	90	100	100	97,50
13	Resources	100	100	100	95	90	95	80	85	90	100	93,50
14	Culture of organization	75	75	50	60	50	65	75	70	80	75	67,50
15	The role of leadership	80	70	60	55	85	60	70	75	70	80	70,50
16	Technological opportunities	100	100	100	90	95	100	95	90	85	80	93,50
17	Industry relationships and cooperation	90	100	95	90	100	80	90	95	100	100	94,00
18	Origin of ownership	40	50	60	70	60	60	65	70	70	80	62,50
19	Features of product/service	90	100	95	80	90	100	95	80	90	95	91,50
20	Innovation strategy	50	50	50	50	50	50	50	50	50	50	50,00

$$\sum S_3^* = 1,659.00$$

Table 12. Matrix of normalized values

No.	Factors	Measures	*	Weight	Values of innovation types		
					T_1	T_2	T_3
1	Clients	m_1	V_1	q_1	d_{11}	d_{21}	d_{31}
....							
10	Regulation/standards	m_{10}	V_{10}	q_{10}			
....							
20	Innovation strategy	m_{20}	V_{20}	q_{20}			
The Sum of Maximizing Variables					S_{+1}	S_{+2}	S_{+3}
The Sum of Minimizing Variables					S_{-1}	S_{-2}	S_{-3}
Value of the alternative					Q_1	Q_2	Q_3
Priority of the alternative					Pr_1	Pr_2	Pr_3

* this can be + or (-), depends on positive or negative effect to innovation activity

Source: Drejeris and Bivainis (2009).

Table 13. The total amount of three alternative averages

No.	Factor	Average, S*			Σ
		T_1	T_2	T_3	
1	Clients	78,00	86,00	96,00	260,00
2	Manufacturers	75,50	88,00	85,00	248,50
3	High cost	70,00	91,50	96,50	258,00
4	Incorrect measures	62,00	86,50	76,50	225,00
5	Competition	92,50	85,00	61,00	238,50
6	Risk	64,50	89,00	89,00	242,50
7	Demand	80,00	87,00	92,50	259,50
8	Company size	64,00	76,00	78,50	218,50
9	Funding sources	75,50	89,50	95,50	260,50
10	Regulation/standards	77,00	93,50	85,00	255,50
11	Staff	80,50	79,00	83,00	242,50
12	Information and knowledge	76,00	94,00	97,50	267,50
13	Resources	78,00	91,50	93,50	263,00
14	Culture of organization	66,00	70,50	67,50	204,00
15	The role of leadership	70,50	73,50	70,50	214,50
16	Technological opportunities	85,50	93,00	93,50	272,00
17	Industry relationships and cooperation	82,00	84,00	94,00	260,00
18	Origin of ownership	38,50	46,50	62,50	147,50
19	Features of product/service	74,50	84,50	91,50	250,50
20	Innovation strategy	50,00	50,00	50,00	150,00

Table 14. Results of multicriteria analysis (made by author)

No.	Factors	Measures	*	Weight	Values of innovation types		
					T_1	T_2	T_3
1	Clients	score	+	0,0562	0,01686	0,01859	0,02075
2	Manufacturers	score	+	0,0529	0,01607	0,01873	0,01809
3	High cost	score	-	0,0503	0,01365	0,01784	0,01881
4	Incorrect measures	score	-	0,0448	0,01234	0,01722	0,01523
5	Competition	score	-	0,0573	0,02222	0,02042	0,01466
6	Risk	score	-	0,0441	0,01173	0,01619	0,01619
7	Demand	score	+	0,0552	0,01702	0,01851	0,01968
8	Company size	score	+	0,0408	0,01195	0,01419	0,01466
9	Funding sources	score	+	0,0497	0,01440	0,01708	0,01822
10	Regulation/standards	score	-	0,0402	0,01212	0,01471	0,01337
11	Staff	score	+	0,0484	0,01607	0,01577	0,01657

12	Information and knowledge	score	+	0,0546	0,01551	0,01919	0,01990
13	Resources	score	+	0,0588	0,01744	0,02046	0,02090
14	Culture of organization	score	+	0,0487	0,01576	0,01683	0,01611
15	The role of leadership	score	+	0,0540	0,01775	0,01850	0,01775
16	Technological opportunities	score	+	0,0510	0,01603	0,01744	0,01753
17	Industry relationships and cooperation	score	+	0,0506	0,01596	0,01635	0,01829
18	Origin of ownership	score	+	0,0366	0,00955	0,01154	0,01551
19	Features of product/service	score	+	0,0537	0,01597	0,01811	0,01961
20	Innovation strategy	score	+	0,0549	0,01830	0,01830	0,01830
The Sum of Maximizing Variables					0,23464	0,25958	0,27188
The Sum of Minimizing Variables					0,07206	0,08638	0,07826
Significance of the alternative					0,32056	0,33125	0,35099
Priority of the alternative					3	2	1

Calculation of the weighted normalized decision matrix (Table 14). The purpose of this step is to receive dimensionless weighted values.

$$d_{11} = \frac{0,0562 * 78}{260} = 0,01686$$

$$d_{12} = \frac{0,0562 * 86}{260} = 0,01859$$

$$d_{193} = \frac{0,0537 * 91,50}{250,50} = 0,01961$$

The sum of dimensionless weighted index values d_{ij} of each factor is always equal to the weight q_i of this factor. Calculation of sums of maximizing indexes (S_{+j}) and minimizing indexes (S_{-j}).

$$S_{+j} = \sum_{i=1}^m d_{+ij}; \quad (10)$$

$$S_{-j} = \sum_{i=1}^m d_{-ij}; \quad (11)$$

$$S_{+1} = 0,01686 + 0,01607 + 0,01702 + 0,01195 + 0,01440 + 0,01607 + 0,01551 + 0,01744 + 0,01576 + 0,01775 + 0,01603 + 0,01596 + 0,00955 + 0,01597 + 0,01830 = 0,23464$$

$$S_{-1} = 0,01365 + 0,01234 + 0,02222 + 0,01173 + 0,01212 = 0,07206$$

Determination of the significance of the alternative based on positive and negative characteristics. The relative significance Q_j of each alternative j is defined as:

$$Q_j = S_{+j} + \frac{S_{-\min} * \sum_{j=1}^n S_{-j}}{S_{-j} * \sum_{j=1}^n \frac{S_{-\min}}{S_{-j}}} \quad (12)$$

The greater significance Q_j , the higher is priority (rank).

$$Q_1 = 0,23464 + \frac{0,07206 * (0,07206 + 0,08638 + 0,07826)}{0,07206 * \left(\frac{0,07206}{0,07206} + \frac{0,07206}{0,08638} + \frac{0,7206}{0,07826} \right)} = 0,32056$$

3.4. Results

The first stage of the survey, where the importance of the factors was determined, shows that most innovation activity in construction sector impacting factor is resources. Usually these resources includes time, which is necessary for develop the innovation, employees, working with this project, money, which should be designate to this innovation. After economic crisis, Lithuanians are afraid to have any dept, and if it is possible, they try to avoid borrowing, unless it is necessary.

The second factor by importance is competition. During the literature review, a lot of authors noted, that competition drives innovations. Some of experts noted, that “healthy” competition must be in every sector; however, it is much better where competition is less.

The last by importance is origin of the ownership.

The second part of survey showed, that the best alternative, according to experts opinion and evaluation, is to build a new residential house, according to passive house standards. All factors and their impact to different kind of project should be analyzed:

1. Clients – according to experts, the biggest impact they have in 3rd alternative. Building new residential house, usually owner (construction companies), has small number of potential buyers, who buy apartments before all construction work is finished. So in this situation, client needs and expectations are most important. During the renovation process (1st and 2nd alternatives), clients are important too, but as already existing customer, not as potential buyer – why their importance are smaller than in third alternative.

2. Manufacturers – the biggest evaluation they got in 2nd alternative – renovation according passive house standards. Experts notes, that construction materials for building renovation you can easily find in Lithuania. Some materials and equipment for passive house you have to search across the Lithuanian borders, there passive house method is widely use – in such case, construction company not just buys materials, but gets useful advises and experience.

3. High cost – as it was expected, this factor do the biggest impact in the 3rd alternative. This factor is considered as negative. Build new house, with new materials, hire experts, conduct new market researches – it is more expensive than to do simple renovation project.

4. Incorrect measures – the biggest importance of this factor is in 2nd alternative, and it is negative. Incorrect counted benefit of innovation projects, the lack of information, makes these processes to be un-attractive to be implemented. People usually count only amount of money, which they have to pay for renovation works, they do not pay attention to future benefits, into the successful experience of foreign countries.

5. Competition – the biggest competition is between construction companies, which perform building renovations. The number of order is low and the number of companies is high. So competition has biggest impact in 1st alternative. There are a lot of construction companies, which build residential houses, but to build a passive house is not the same, because construction company:

- Will become first on the market with unique product;
- Significant attention from media channels (advertisement for free);
- Huge public interest, and potential buyers;
- Opportunities for additional funding sources (depends on the project).

6. Risk – this factor got the same evaluation in both of 2nd and 3rd alternatives. There is the bigger risk, because these new processes are not well tested in Lithuania – there can be problems with manufacturers, regulations, performed incorrect measures about demand, benefit, and market trends. There is opportunity to get more benefits from both of projects if they will be successful, or to experience losses.

7. Demand – the higher demand, the easier to operate. Demand has biggest impact in 3rd alternative, because this would be the novelty in Lithuania, and it is very important, that first project would be successful and create the demand for such kind of products – flats in passive residential houses.

8. Company size – this factor is not very important among all three alternatives. The biggest importance is considered to be in 3rd alternative. It is logical decision; because it is easier for large companies to find funding sources, to cooperate with other companies, these companies usually have their potential customers.

9. Funding sources are most important for the 3rd alternative. To build a new residential house always requires bigger investment than to renovate old one.

10. Regulations / standards – are similar for all construction works. The bigger importance is for 2nd and 3rd alternatives, because regulations are new, and disadvantages or changes occurs only after a certain time.

11. Staff - evaluation very similar for three alternatives. Qualified employees are valued in the same way.

12. Information and knowledge - are most important in implementing something new, in this situation, building new residential house according to passive house standards. It is very important to have full package of knowledge about all needed materials, about all installed technologies and etc.

13. Resources – this factor has the biggest rank. This has biggest impact in new constructions, because the intensity is bigger, the cost is higher.

14. Culture of organization – this factor is not so important among construction companies, as it was in literature review. The construction is a sector, where creative is less important comparing with other sectors. Constructions are strictly bounded by regulations and standards. The biggest importance is for 3rd alternative, because it is necessary to take over other countries experience, and there is a possibility to change something, to offer new things, to find the gap, where your ideas and creativity can be evaluated.

15. The role of leadership – “it is important to have person, who always seeks for new possibilities and opportunities”. This must be experience and creative person, who can help to reach companies goals. Usually leader is company’s director (not owner).

16. Technological opportunities and industry relationships also have the biggest impact for 3rd alternative. Cooperation between companies or research institutes leads to achieve the best result, to share risk, knowledge, information and cost, together to have greater technical capacity.

17. Features of product/ services are very similar for three alternatives – construction works. This factor will have the bigger impact if different sector were compared.

CONCLUSIONS AND RECOMENDATIONS

After literature review and research, were made following conclusions:

1. Lithuania's innovative performance is weak, and comparing with other EU countries, is well below the EU27 average. . Lithuania should strengthen its' cooperation with other, more innovative countries, such as Denmark, Finland, Sweden. The common projects will lead to gain more skills, knowledge and experience.

2. The 20 key factors were found during the literature review, which may impact innovation activity. The most popular and one of the most important factors were identified as "Culture of organization", according to the science literature. The least important factor is "Origin of ownership".

3. The construction sector is considerably weakened due to economic crisis. Construction - one of the most important sectors in modern economic and it is not tend to innovate. Only 20 percent of construction companies are innovative. This reduces competitiveness of this sector among the international companies. This situation must be changed. Government could pay more attention to construction sector; support it, to encourage innovations in this sector, try to involve construction companies in EU support programs. The government of Lithuania should pay more attention to increasing demand of innovative product/ services. This can be done trough public procurement system of innovative products

4. The evaluation of the factors, impacting innovation activity in construction sector, by experts, showed that highest impact has "resources". Before implementing something new or just improve already existing processes, companies always evaluate their available resources – time, money, employees and etc. Enterprises, which do not have enough internal resources, do not even think about developing any kind of innovation. The second factor by importance is competition. This factor has negative impact. Competition between companies not just encourages innovations, but also destroys the weaker companies. The research showed that large companies rated "competition" not as very important factor that did smaller companies. The third factor by importance is "clients". This factor is one of the most important in almost all sectors, because they are purchasing power and they generates cash flows. Company's success depend on how satisfied is the customer. The least important factor is "origin of ownership".

5. Evaluation of three alternatives revealed, that preferred alternative was build the new residential house, according to passive house standards. This means, that it is better to

take the high risk, pay the high cost for innovation, use internal resources, have dept, but to be the first in the market and to get all the benefits. Experts have noted that word “renovation” is not popular in these days – people do not trust on created mechanism of old building renovation. In this case, 1st and 2nd alternatives were less attractive than 3rd alternative.

6. All factors, identified by literature review and evaluated by their importance by experts, can be strategically managed to maximize innovation outcomes. Companies, which try to create and implement new innovation, should pay more attention to these factors, which may impact their innovation. These companies should evaluate these factors by importance or to use data from this research in their future decisions and plans. This would help to avoid some failures.

7. Almost all factors had the biggest impact in 3rd alternative – positive and negative. This confirms, that the higher level of innovation, the more factor may impact its’ development. This research has also confirmed that factors may impact differently in some projects, so the best assessment of these factors is individual and limited only for evaluated project.

8. It is necessary to build strong relationships between companies and research institutes, stimulate cooperation among enterprises; there is limited information about benefits, which may arise from such cooperation. Is should be noted that the best way to see or show the results – to present particular examples.

9. It is recommended to integrate gained experience of the project into continuous business processes to limit the loss of knowledge between projects.

10. It is appropriate to use this research results and conclusions in similar studies, also in formulating innovation policy and strategic management of innovations.

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APPENDICES

Annex A

Questionnaire

The evaluation of factors impacting innovation activity in construction sector

I am a master of Business Management Faculty, VGTU, currently carrying out the research, which main purpose is to identify the main factors, impacting innovation activity in construction sector. I assure the anonymity of your responses. These data will be used only for statistical analysis.

Questionnaire

No.	Questions		Answers
1.	Your age?	up to 22 years	
		23-31 years	
		32-40 years	
		41-49 years	
		50 years and more	
2.	Your education?	Secondary	
		Professional	
		Higher	
3.	Your acquired specialty?	Construction Engineer	
		Architect	
		Manager	
		Lawyer	
		Economist	
		Other (name)	
4.	Your sex?	female	
		male	
5.	An organization, where you work, is engaged in the following activities:	Construction works	
		Sale of materials	
		Design (architecture and/or technical projects)	
		Building maintenance	
		Investment	
		Project management	
6.	Your work experience in construction sector:	1–3 years	
		3–5 years	
		5–10 years	
		>10 years	
7.	Do you consider company, in which you are working now, as innovative?	Yes	
		No	

Annex A, continued

Please evaluate the each factor in the hundred-point system in order of importance.

No	Factors	Score (1-100)
1	Clients	
2	Manufacturers	
3	High cost	
4	Incorrect measures	
5	Competition	
6	Risk	
7	Demand	
8	Company size	
9	Funding sources	
10	Regulation/standards	
11	Staff	
12	Information and knowledge	
13	Resources	
14	Culture of organization	
15	The role of leadership	
16	Technological opportunities	
17	Industry relationships and cooperation	
18	Origin of ownership	
19	Features of product/service	
20	Innovation strategy	
		The maximum amount of 2000 score

The description of the above factors:

1. Clients – companies must adapt and respond into the customer needs, seek for a new solutions that customer will be satisfied.
2. Manufacturers – if they introduce new product or service on the market, the users have to react into this novelties and to adapt them into their activities (for example, the introduction of new construction material on the market makes and construction companies to re-design and upgrade their processes, in case to adapt these novelties).
3. High innovation cost – the development of the product or improvement of existing one always requires additional funding, because it is necessary to hire experts, to carry out new researches.
4. Incorrect measures of innovations benefit – usually is measured profit and return, such things as reputation, knowledge and added value are not measured.
5. Competition – the more intensive competition the more companies are tending to innovate, because it helps to stay on the market and to stand out others.

Annex A, continued

6. High risk – risk may arise in every step of innovation process – carrying out the researches and making calculations, making contracts, looking for funding sources and etc. – there is always risk, that innovation can be unsuccessful.
7. Demand of innovative products/ services – if demand for innovative products is big, companies tries not to fall behind, but to improve their process that could offer such products.
8. Company size – small companies have more difficulties and barriers than large firms to access and absorb the knowledge, to establish collaborations required for their innovation activities.
9. Funding sources – government support, EU funds, bank loans and etc.
10. Regulations /standards– all the legal database that regulates innovation and their development.
11. Staff – the lack of qualified employees in companies often have a significant impact on the development of innovations.
12. Information and knowledge – accurate information about the competitors’ actions, market trends, the conditions for aid and etc, helps companies to reduce the risk for the future failures.
13. Resources – these resources can include time, which is spend on innovation activities, number of employees, dedicated to this activity, amount of investment, which is needed for equipment and etc.
14. Culture of organization – new ideas are promoted within the company, no punishment for the bad ideas, cooperation and sharing of ideas among the employees.
15. The role of leadership – company’s “soul”, who is the main initiator of innovation development, create added value, is qualified, experienced, has skills and knowledge.
16. Technological opportunities – existing technological capacity and the ability to implement new technologies.
17. Industry relationships and cooperation – cooperation with other companies, clients, research centers, consultants and etc.
18. Origin of the ownership – foreign-owned firms are often more susceptible to innovation, which applies in other markets already tried and proven processes, than Lithuanian capital firms.
19. Features of product/service – for some products/ services are easier to implement new innovations, for other – difficult, because of differences in manufacturing processes, life cycle, etc.
20. Innovation strategy – correct choice of innovation strategy, taking into account all the available resources, knowledge and capabilities gives a positive result, while in-correctly chosen strategy can only bring losses.

Annex A, continued

Please evaluate the three alternatives, according to the factors, impacting each of them

No	Factors	1 st Alternative Score (1-100)	2 nd Alternative Score (1-100)	3 rd Alternative Score (1-100)
1	Clients			
2	Manufacturers			
3	High cost			
4	Incorrect measures			
5	Competition			
6	Risk			
7	Demand			
8	Company size			
9	Funding sources			
10	Regulation/standards			
11	Staff			
12	Information and knowledge			
13	Resources			
14	Culture of organization			
15	The role of leadership			
16	Technological opportunities			
17	Industry relationships and cooperation			
18	Origin of ownership			
19	Features of product/service			
20	Innovation strategy			
		The maximum amount of 2000 score	The maximum amount of 2000 score	The maximum amount of 2000 score

Description of the alternatives:

1st Alternative – sustainable innovation – the simple building renovation project.

2nd Alternative – breakout innovation – the building renovation project, according to passive house standards.

3rd Alternative – disruptive innovation - the new residential building project, according to passive house standards.