VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

FACULTY OF MECHANICS

DEPARTMENT OF MECHANICAL ENGINEERING

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IMPROVEMENT INTEGRATION OF SCIENTIFIC INSTITUTIONS R&D ACTIVITIES INTO INDUSTRIAL ENTERPRISE ACTIVITIES

MOKSLO INSTITUCIJŲ MTTP VEIKLOS INTEGRAVIMO Į PRAMONĖS ĮMONIŲ VEIKLĄ GERINIMAS

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Annotation

In this Master's degree Thesis a problem of collaboration difficulties between scientific institutions and industrial enterprises is analysed. Current literature on the subject and current situation of the subject is reviewed and assessed.

Research was done to assess the possitive impact of R&D and innovations to industrial companies and confirm the need for collaboration. Data from Lithuanian, Estonian and Latvian countries was evaluated. Further research was mainly done usig data gathered from Lithuanian industry companies. Research was conducted using quantitative research methods and statistical data analysis.

Structure: Introduction, Literature review and assessement of current situation, Research and result analysis, Concept model presentation, Model implementation, Possible future of the model, Conclusions, References, Annexes.

Volume of thesis – 66 p., 23 pictures, 2 tables, 51 references.

Keywords: R&D, innovations, collaboration, statistical analysis, industry, data base, universities, project financing, knowledge dissemination, classification.

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Antrosios pakopos studijų **Pramonės inžinerijos ir inovacijų vadybos** programos magistro baigiamasis darbas 4

Pavadinimas	**Mokslo institucijų MTTP veiklos integravimo į pramonės įmonių veiklą gerinimas**
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Anotacija

Baigiamojo darbo temoje nagrinėta pramonės įmonių ir mokslo institucijų bendradarbiavimo sunkumų problema. Buvo apžvelgta ir išanalizuota literatūra šia tema bei įvertinta dabartinė situacija.

Tyrimų tikslas buvo įvertinti teigiamą MTEP ir inovacijų naudą pramonės įmonėms ir patvirtinti poreikį bendradarbiavimo vystymui. Įvertinti Lietuvos, Latvijos ir Estijos pramonės įmonių duomenys. Tolimesnis tyrimų etapas buvo atliekamas surenkant informaciją iš Lietuvos pramonės įmonių ir apdorojant rezultatus statistiniais metodais.

Struktūra. Įvadas, Literatūros apžvalgą, analizė ir dabartinės situacijos vertinimas, Tyrimai ir rezultatų analizė, Koncepcinio modelio pristatymas, Modelio įdiegimas, Modelio ateities plėtros planai, Išvados, Literatūros sąrašas, Priedai.

Baigiamojo darbo apimtis - 66 p., 23 paveikslėliai, 2 lentelės, 51 literatūros šaltinis.

Prasminiai žodžiai: MTEP, inovacijos, bendradarbiavimas, statistinė analizė, pramonė, duomenų bazė, universitetai, projektų finansavimas, žinių sklaida, klasifikavimas.

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Introduction

Problem. Faced with the challenges of increased globalization of markets and of technological change, enterprises need reinforced support through national and foreign research cooperation to enhance their innovation and research investment. Manufacturing enterprises survival depends on their capability to improve their performance and produce goods that could meet international standards. In other words, a certain level of competitiveness may be a prerequisite for a manufacturing enterprises survival when dealing with dynamic conditions in the business environment. To compete with global competition and, overcome the rapid technology change and product variety proliferation in the new manufacturing environment.

This competitiveness realized the need of alliance capitalism to meet these challenges and resulted in cooperative agreements and joint R&Ds. Internal R&D, hiring external R&Ds, internationalization of R&D, R&D clusters, inter-firms collaborations, and R&D collaborations with universities are different sorts of cooperation and have been practiced by different business magnates to maintain the innovations on tracks for competition survival. Academia-industry collaborations have been encouraged in many countries by Policy-makers. Universities play the role of an economic actor and create new motor for economic development. Entrepreneurial universities are encouraging their researchers to commercialize their knowledge with industry for getting research pecuniary incentives. On the other hand, industries solve specific technical or design problems to develop new products for more competitive advantages. This is the reason for a weak attitudinal alignment between firms and faculty as researchers at institutions have inclinations towards leaky knowledge to share their ideas with their colleagues and researchers but firms to be sticky for their knowledge to avoid any leakage of knowledge for competitive advantages.

Relevance of work. Cooperation between industry and scientific institutions can be defined as the link which joins basic research (carried out at universities, laboratories and research centers) with applied research (come to fruition in industries) in such a way that, as a result of a joint action by both parts, synergies can be created which lead to the improvement of the economic and technological potential of partners that cooperate, and consequently, to increase the level of competitiveness of countries. The key in increasing collaboration between industry and scientific institutions is to enable new knowledge creation and transfer in and to enterprises from universities and other scientific institutions is the development of collaborative environments and networks to increase their innovation capabilities as a single unit but also the capabilities of the network as a whole through collective learning and collaborative projects.

Aim. To condition collaborative relationships between manufacturing enterprises and scientific institutions by using new methods of classifying the services / patents and Research and Development knowledge from scientific institutions and making them easily accessible to the manufacturing industry.

Tasks:

1. To identify topicality, importance and problematic relations of the problem;
2. To perform a scientific research about the need of collaboration between scientific institutions and industrial enterprises;
3. To present a viable model that can be used to condition the relations between science and industry;
4. Implement this model with tangible examples and assess its importance to the relations between science and industry;
5. Introduce the possible future model and assess possible future development of the model.

Novelty. R&D is a worthful social experiment that can add values in the innovation process and contributes for national economy. Lack of innovation can push any organization out from business. At this point in time there is no easy to use universal model for collaborating and exchanging knowledge between scientific institutions and industry companies in Lithuania.

Practical value. Implementing scientific institutions services classification model would enable research and business collaboration and give rise in R&D funding, which would be attracted from the private sector and would help to move closer to the EU average in the Innovation Union Scoreboard. Also it would create opportunities for Lithuanian and foreign businesses, research and academic institutions, researchers and other interested parties and give an easy and convenient access to information about Lithuanian research and development (R&D) services, and implementation of research projects.

1. Research and Development (R&D)

1.1 About R&D

The research and development (R&D, also called research and technical development or research and technological development, RTD in Europe) is a specific group of activities within a business. The activities that are classified as R&D differ from company to company, but there are two primary models. In one model, the primary function of an R&D group is to develop new products; in the other model, the primary function of an R&D group is to discover and create new knowledge about scientific and technological topics for the purpose of uncovering and enabling development of valuable new products, processes, and services. Under both models, R&D differs from the vast majority of a company's activities which are intended to yield nearly immediate profit or immediate improvements in operations and involve little uncertainty as to the return on investment (ROI). The first model of R&D is generally staffed by engineers while the second model may be staffed with industrial scientists. R&D activities are carried out by corporate (businesses) or governmental entities.

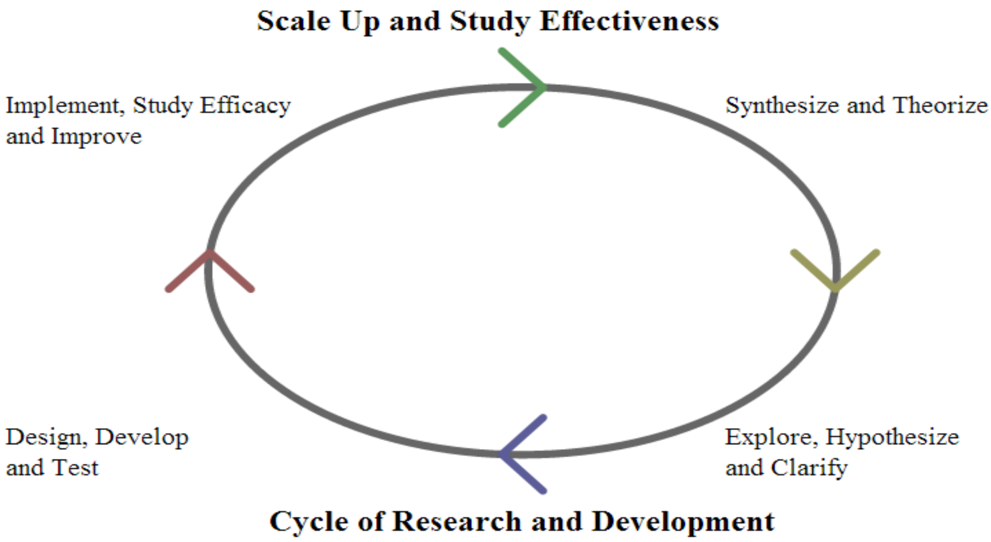

Fig. 1 Cycle of research and development (REESE, 2009)

New product design and development is more often than not a crucial factor in the survival of a company. In an industry that is changing fast, firms must continually revise their design and range of products. This is necessary due to continuous technology change and development as well as other competitors and the changing preference of customers. Without an R&D program, a firm must rely on strategic alliances, acquisitions, and networks to tap into the innovations of others.

Levy (2002) says that a system driven by marketing is one that puts the customer needs first, and only produces goods that are known to sell. Market research is carried out, which establishes what is needed. If the development is technology driven then R&D is directed toward developing that market research.

In general, R&D activities are conducted by specialized units or centers belonging to a company, or can be out-sourced to a contract research organization, universities, or state agencies. In the context of commerce, "research and development" normally refers to future-oriented, longer-term activities in science or technology, using similar techniques to scientific research but directed toward desired outcomes and with broad forecasts of commercial yield.

Statistics on organizations devoted to "R&D" may express the state of an industry, the degree of competition or the lure of progress. According to literature (Levy D, 2002) some common measures include: budgets, numbers of patents or on rates of peer-reviewed publications. Bank ratios are one of the best measures, because they are continuously maintained, public and reflect risk.

On a technical level, high tech organizations explore ways to re-purpose and repackage advanced technologies as a way of amortizing the high overhead. They often reuse advanced manufacturing processes, expensive safety certifications, specialized embedded software, computer-aided design software, electronic designs and mechanical subsystems.

Research has shown that firms with a persistent R&D strategy and innovation policy outperform those with an irregular or no R&D or innovation investment program.

1.2 R&D in Lithuania

Following the experience of other countries with high achievements in the field of innovation (Finland, Sweden, Norway, the Netherlands, Ireland and Great Britain) in 2010 Lithuania approved the first large-scale Lithuanian Innovation Strategy for the Year 2010-2020 (the Strategy). It is a long-term strategic planning document which sets vision, objectives, goals and results to be achieved in the field of Lithuanian Innovation up to 2020. The goal of the decade's vision is reach the European average till 2020.

The long-term objective of innovation policy is to build a creative society and create conditions for the development of entrepreneurship and innovation. The implementation of this objective is intended along four principal directions:

1) Enhancing the Lithuanian integration into the global market ("Lithuania without borders");

2) Educating a creative and innovative society;
3) Developing broad-based innovation;
4) Implementing a systematic approach to innovation.

The Strategy distinguishes these high innovation potential sectors:

- Biotechnologies and laser technologies;
- Industry of electricity and optical equipment;
- Clean technologies;
- Future energetic;
- Creative industries;
- Welfare and wellness.

Immediate to the Strategy Lithuania drafted and approved the Implementation Action Plan for the year 2014-2017 (the Action Plan) defining the specific measures to attain the objectives established. The Action Plan encompasses diverse financial instruments to promote the business and science sector co-operation, develop innovation activities of enterprises, streamline the services of the public sector, improve the competence and capacities of human resources, as well as numerous non-financial measures that will contribute to the development of the environment favorable to innovation.

1.3 R&D funding

It is known that research and development is one of the major factors encouraging economic growth and competitiveness. According to current situation, in Lithuania R&D is done by universities, research institutes and some private businesses.

Experimental development, which is also known as applied scientific activities, is systematic work based on the accumulated knowledge of research and practical experience. Its goal is to create new materials, technologies, products and equipment, introduction of new processes, systems and services, or a substantial improvement of the existing ones.

According to The Official Gateway of Lithuania the state funds part of R&D conducted at research organizations and universities. This is done to promote the commercialization of the scientific activities as well as build closer interaction between science and business.

In view of Lithuania's economic and cultural needs, prospective areas of science are identified and promoted, independent development of science is encouraged, and attention is given to adequate professional training of scientists. Young scientists and their creative activities are also taken care of.

Currently, institutions can count on funding from the International programs like HORIZON 2020, FP7, EUREKA. EUROSTARS. BSR Innovation Express.

1.4 R&D collaboration

Since the 1980, many countries have implemented policies to facilitate the transfer of knowledge from universities to companies: establishment of legal frameworks, creation of technology transfer offices inside universities, increasing the mobility of researchers to industry, large cooperative R&D programs, etc. Some analyses show that these policy measures have contributed greatly to increasing the number and the scope of links between the two worlds. However, there is no clear evidence on their economic impact. The relationship between university and industry is a complex phenomenon. Actually, the channels used by firms to draw out knowledge developed by public research organizations are diverse. The intensity of links varies across firms, sectors and countries.

1.4.1 Collaboration types

There are a number of categories and subcategories of R&D collaboration. The various categories demand that strategy selections be undertaken for finding the most suitable form of collaboration for a project. The decision-making process may be long, troublesome and time-demanding. Actually, there are as many strategy selections as there are collaborators. According to Thomas (2003) the most important R&D collaboration categories can include more detailed subcategories that are listed below with additional commentary:

- **University sponsoring/cooperation:**

  Subcategories that can be included are:

  1. Thesis works;
  2. Sponsored research;
  3. University with a research consortium;
  4. University professor;
  5. Specific institution, faculty or university institute.

Thesis works. Practical thesis works of a single person, such as a master's, diploma or doctorate thesis. It is a typical example in this category. The best example would be engineering students who, at the end of their studies, may write their diploma work for a research laboratory in a large enterprise.

Sponsored research. A sponsored research model can be used when a university is doing high-quality and high-intensity research on research fields that are of interest to the enterprise, but where the applications of the research are not yet clear enough for other approaches. One can, for example, support the university's activities by donating resources to buy important research equipment.

University with a research consortium. This category typically is funded when there is clear added value in conducting the research as a consortium. Thomas (2003) says that the added value may come from the cooperation inside the consortium and/or from aggregating critical R&D resources. And because there are many types of consortiums, e.g., a collaboration project where there is a university, an enterprise, two companies functioning as subcontractors and a national research institution, it can be true. However, the management of a large consortium may be especially complicated and problematic to maintain for a longer period of time, which in its own accord can ruin the future possibility of gaining knowledge.

University professor. University professors can be financed if they are the key researchers of the area in question. In this category, professors can get resources through their university for doing research on an area of their expertise.

Specific institution, faculty or university institute. For example, a research institution receives financial resources from a large enterprise for doing research on a specific topic/module. In the majority of such cases, a university has done excellent research on the topic over a long period of time. According to literature in these cases, universities typically are active in marketing their work to an enterprise to get additional funding and top-class guidance in helping them find the industrial relevance for their research. Sometimes an enterprise recruits researchers from such projects and tries to give a positive impact to the level of education as a result of country or specific strategic business reasons.

- **A company as R&D collaborator:**
    1. Large collaboration project;
    2. Resource hiring or subcontracting from a company;
    3. Module, design or unit;

4. International resource hiring.

Large collaboration project. An example of this is an enterprise having a multimillion-dollar R&D project with a collaborator. This can be a slippery slope for universities because using companies in R&D may be challenging because they may lack some competencies. Therefore, companies in R&D mostly are used for specific research where more straightforward tasks already have been identified. However, this is case-specific to a high degree.

Resource hiring or subcontracting from a company. Resource hiring is a rather straightforward extension of an enterprise's own resources. It is mostly used in cases where tasks are defined and can be given to an external person having the necessary skills. The skills hired typically are based on old working cooperation/relationships. According to literature the business relations can be domestic/international, on site or offshore.

Module, design or unit. A part (module/design/unit) of the working total is ordered from an R&D collaborator. These mostly are fixed-price subcontracting projects. The part is delivered, tested and then integrated into the whole product.

International resource hiring. Generally speaking, this category has become increasingly used in many large organizations during the last few years. A specific challenge to international resource hiring cases is that it may be difficult to verify that ethical principles required and demanded by the enterprise are followed. For example, a resource hiring company placed in country A, renting personnel from country B to an enterprise in country C, may provide a cost/benefit to the enterprise hiring the resource. However, a possible drawback is that it might be difficult to ensure that this arrangement fulfils the employment/employee regulations in all the involved countries, that appropriate ethical principles are followed in respect to the employees and that the enterprise's values are fully understood and followed.

- **Special variants of R&D collaboration:**
    1. Collaborator's subcontractor;
    2. Ad hoc R&D subcontracting;
    3. Alliance or cooperation forum;
    4. International R&D projects.

Collaborator's subcontractor. This also includes any subcontractors of the R&D collaborators (who also may have their own subcontractors). The key business rule is to check and assess topics such as confidentiality, security, contractual requirements, third-party intellectual property rights (IPR) principles, product liability, assessments of the collaborator/subcontractor and warranties. One also has to be careful that collaborators and their subcontractors do not get the opportunity to participate in internal discussions where they might get patentable ideas. This aspect has to be considered in all subcontracting categories, but this is a case-specific issue. Information security is naturally of special importance in this category. However, this is case-specific, as there may exist tight collaboration, more of partnership. In partnership, a deep and long-term collaboration is in question, where the driving forces behind the partnership are the carefully mapped-out benefits for both parties and mutual trust. Further, in this category it is of especially great importance to achieve a win-win situation.

Ad hoc R&D subcontracting. R&D subcontracting ad hoc would be necessary in a case where, for example, the project is at risk of being late, the researchers are sick and, with the existing resources, the project will not remain on schedule. This kind of ad hoc R&D subcontracting is mostly done on an hourly basis. In such cases, the use of existing collaborators (i.e., those already in use by another unit/department within the organization) is recommended to keep up existing timetables until a new suitable and reliable collaborator can be found if necessary.

Alliance or cooperation forum. Although this is a tight form of collaboration, it is looser than a joint venture. This type of alliance may create a natural potential collaborator and subcontractor base for all the interested and participating companies and may speed up technology take-up and ramp-up of global developer communities, as well as facilitate global standardization of (future) core technologies.

International R&D projects. Examples are projects financed by the European Union (EU). EU-financed projects in R&D and in the area of IT are large, usually have several participants and run in several European countries. The participants mostly are universities, enterprises, research institutions, collaborators and interest organizations. EU projects usually have specific contractual obligations that must be considered and included in the collaboration legal agreements.

1.4.2 Collaboration between industry and universities

Industry-University collaboration is known as the vital form of learning where university tends to gravitate more towards knowledge contribution while companies are involved in dealing with the uncertainties of innovation and accessing exploration and potential profit/loss. It is universally acknowledged that universities are major sources of new knowledge, ideas and novelty, particularly in the field of sciences and technology (Etzkowitz H, 2000). Motives like publication records, institutional affiliations and prizes for uprising the status competitions with the peers have triggered the researchers at academic institutes to engage R&D activities. This has created a race for increasing the research publications. This gesture also has forced the states and governments to enhance supports for R&D activities. As a consequence, researchers have put immense efforts to examine the nature and importance of the associations between universities and industry, building clear image of mechanism which may support this interaction; resulting in advancing knowledge transfer and acquisition.

According to Fiaz (2012) recently, the significance of R&D collaboration has been focused by many researchers, as a source to enhance the impact of R&D on economic growth by improving the R&D productivity and technological dissemination. Particularly, R&D relationship between the innovating firms and public R&D institutions i.e. universities are considered as a channel to support knowledge sharing and R&D spillovers. This can lead towards the realization of University-Industry collaboration by associated innovating firms.

1.4.3 Sustainable university-industry collaboration

There are numerous factors that lead the partners towards sustainable University-Industry collaborations. To make a sustainable relationship is important when trying to get the most of collaboration. When assessing current literature these main factors were found that can have impact on sustainable science-industry collaboration:

Novelty and innovation. Similarities of technological bases among partners may be detrimental for learning and innovation (Nooteboom B, 2000). Organizations with innovative tendencies have to face the ever-growing technological challenges and complexities. These challenges can be met by proceeding in a certain circumstances for R&D activities. Innovation may be of different type depending upon the strategy used by the firm; Product innovation, process innovation, innovation for the market and innovation for firm. Collaboration propensity for R&D projects is affected by the type of innovation. Innovation for the market and innovation for firm are alternatively distinguished forms of innovations (Annique U, 2009).

Magnitude of firms. Bidirectional arguments have been observed in terms of the effects of firm size as a motivating factor for University-Industry R&D collaborations and its sustainability. In Germany, universities have been reported to prefer collaborations with big firms and universities. Reason is their better financing capacity and the scientific orientation of their research (Beise M, 1999). The frequency of innovation is directly proportionate to the firm size (Warda J, 1995). Large firms are considered more reliable for R&D collaboration due to having core competencies for a specific product or service and allocation of large budgets under R&D budget heads. Supports for large firms have also been inclined by that large firms are better able to carry R&D activities than smaller ones, since they benefit from economies of scale and scope. In Canada, large firms are also more inclined, compared to small firms, to get involved in partnerships with universities (Warda J, 1995).

Openness potentiality. Openness is sharing the strategic information with competitors (Hippel E, 1987) for development activities. Collaborating firms mostly like to use the exiting knowledge base for easiness and reusability of articulated R&D intellectual property. Firms having more tendencies towards using exiting knowledge domains for innovation process have been observed to make more alliances. Research work of (Mansfield E, 1998) and (Belderbos R, 2004) believe that external knowledge flows have great influence to collaborate in R&D projects with the other firms. However, (Lo´pez A, 2008) has belief that the incoming spillovers reflect the importance of available public knowledge. There is a significant relation between incoming spillovers and the decision to collaborate in R&D. In addition, the higher the incoming spillovers are, the greater the scope for learning within R&D collaborations, and hence the greater is the marginal profit to be derived from collaboration.

R&D intensity. R&D tendency of the firm is to collaborate with the other firms. Empirical research analysis for choice of collaboration in Belgian manufacturing firms suggests that R&D capacity affects the decision to collaborate with universities. R&D capacity of a firm can be assessed by scrutinizing the internal sources of knowledge owned by the firm. The other way to asses R&D capacity is firm's R&D intensity. R&D intensity is an indicator of the firm's absorptive capacity (Cassiman B, 2002). Empirical studies have shown that firms' absorptive capacity depends on their own R&D intensity and the benefits from R&D collaboration depend on the absorptive capacity of the firm (Belderbos R, 2004). Another line of empirical research has specifically taken into account the symbiotic relationship between R&D collaboration and in-house R&D activities (Colombo MG, 1996).

Ratio between R&D employment and total employment. Another factor that contributes towards the collaboration is the presence of Research and Development work force in certain organization. Higher the R&D professionals, greater are the chances for the innovation and development. The R&D employment ratio directly affects the market economy and attracts the collaborating partners for shared activities.

Core competencies. The collaboration is always executed due to the presence of some core competencies among the partners. Industry owns the hardware and Academia enjoys the researchers' pool. This results in sharing of competencies that effects the collaboration. The big companies make use of their core competencies to attract small companies and academia for joint venture and alliances.

Degree of R&D collaboration. The propensity of University-Industry alliance depends on the need of both partners and it is executed as a win-win enterprise. The degree of collaboration varies from firm to firm and project to project as sometimes sharing is restricted due to secrecy and goals definition. The trends of University-Industry alliances have been increased drastically in the last decade due to the need of highly skilled research force and due to the involvement of high gross budgets.

Overcome the method complexity. Complexity plays a pivotal role in the execution and realization of R&D budgets. The alliances cause the complexity too but they can be used as an agent to reduce the project complexity. A vast research has been done in the past to describe the project and alliances complexity in a quantitatively and qualitative manner.

State support. State is proved to be a catalyst for materializing the alliances between academia and industry. The state support in the form of security, taxation, laws, regulations and policies greatly affect the partnerships and the favorable conditions accelerates such partnerships.

Proper and positive communication. Communication gaps may cause the distortion of sustainability University-Industry R&D collaborations. Positive and proper communication leads towards smooth execution of R&D projects. Problems of communication and mutual understanding can be due to technological diversities (Nooteboom B, 2000).

Finding new partners. Finding new partners is directly related with trust and prior ties. Prior ties for R&D collaboration have strong influence on the choice of future partners and leads towards increased trust among partners (Zucker LG, 1987).

Trust. Very important factor for sustaining the University-Industry collaboration among partners is trust as it allows partners to be confident for avoiding the information and innovation leakages and treating fairly to resolve all sorts of problems during joint project executions (Rempel JK, 1986). Higher level of trust among partners stimulates to exchange valuable knowledge and information (Ring PS, 1992).

Generation of knowledge. A series of empirical studies confirms that technological development, innovations and growth in private sector, novel theoretical insights, new techniques and skills that usually difficult for companies to find and access, can be made possible by generating academic knowledge and contribution for future technologies. Author (Griliches Z,

1994) have examined the relationship of academic knowledge with the business growth and heralded the university-industry collaboration as complex phenomenon.

1.5 University-industry collaboration barriers

Followings are main barricades for University-Industry collaborations. If these barriers are not carefully addressed by both partners, collaborations may be weakened or even come to an end without fruitful and desired results. For this reason, these barriers should be carefully accosted prior to collaboration. Difference between the academic and industrial approaches, their mutually exclusive preferences and working environment may cause discrepancies among the partners. Therefore, a common platform is needed to overcome or reduce the gap between collaborating allies and to align the strategies for mutual benefits and appropriate gains.

Innovation barriers. R&D collaboration is needed to facilitate a firm to overcome the barriers or difficulties that arise due to technological complexities and innovative activities during execution of joint R&D projects. So, collaboration leads to reduce and overcome these barriers or difficulties. Different reasons for collaboration have been discussed but the ability to share cost and risks is important for the success of R&D collaboration (Becker W, 2004). Studies (Mansfield E, 1998) weighed three measures for innovation hampering faced by a firm and these potentially push the firm to collaborate: cost constraints, risk constraints, and organizational capability. Thether (2002) presented the list of innovation process difficulties and use of collaboration to reduce these difficulties: stakeholders' response to innovation, organizational behavior and inadequacies, availability and cost of finance for innovation, difficulties with regulations or standards.

Priorities. Both partners have different priorities due to different cultures. Researchers mostly prefer for delivering knowledge but firms are output oriented in the form of production. Similarly, increasing publications for establishing reputation is prioritized for academe researchers for career sustainability and is based on basic research while industrialists are interested in applied research. Due to lack of practicalities, academics have to cooperate with industry. Lack of basic research forces firms to collaborate with academia in order to gain competitive advantage (Teece D, 1986). An industry prioritizes on focused and immediate results while researchers take long time for research process.

Difference of culture. Cultural difference is considered as a major barrier for cooperation among partners and has deep influence on R&D collaborations outcomes (Bloedon R, 1994). Vital role of researchers is required to focus on this dimension of University-Industry collaboration research. If cultural differences are minimized among these two props, more incentives can be gained by mutually understanding and reducing R&D barriers.

Established procedures deficiency for university-industry collaboration. Due to absence of mature and formal procedures for University-Industry collaboration among partners, cohorts may attempt to capture commercial paybacks for competitive advantages. Lack of proper procedures and agreements due to unrealistic expectations about the commercials benefits can lead to conflict over R&D knowledge reserves and disclosure of results.

Absorptive capacity. Firms' ability to create signification, gains and sustains a competitive advantage through the management of the external knowledge (Camisón C, 2010). Due to scarcity of this property, organization fails to sustain the cooperation process especially with academia partners. Absorptive capacity of a firm is related with firm size.

Lack of trust. High levels of uncertainty is involved in University-Industry collaboration for R&D projects as research process is beset with unknown results and outcomes. This may be due to lack of competent teachers or non-involvement of practitioners in the curriculum preparation. These scenarios cause the partners to seek advantages and benefits of the competition through knowledge leakage (Williamson O, 1993). This lack of trust always results in damaging the collaborations.

Lack of interest. Lack of interest of some faculty members with research or practitioners' personal conflict with research groups is a big hurdle. Not all the researchers at universities have industry exposures and so not very much interested for making alliances with industry. Firms, on the other side can also face a problem for broad based knowledge and lack of clarity in trainings and disciplinary requirements. Priorities to production and teaching are also influence the interest of University-Industry collaboration participants.

Knowledge and technology detonation. Researchers at educational institutes want to leak knowledge for sharing the research and newness of their ideas to be acknowledged but enterprises don't want to share their research outcomes for avoiding their partners to get competitive advantages for this novelty and so want to be sticky for their R&D knowledge. Intellectual property protection, privacy, technological copyrights, secrecy, and knowledge transfer are the basic challenges and threats related to such alliances (Brown JS, 2000).

1.6 The concept of cooperation between firms and universities

Although in general there is a consensus that technological innovation is a key determinant of long run growth, there is still an unresolved debate as regards which factors encourage the process of innovation itself. To shed light on these factors, a useful starting point is a set of stylized facts well documented by the empirical literature:

- First fact that can be found in the literature (Rosenberg N, 1982) is that learning is not a linear process that begins in the scientific laboratories and moves onwards to the firm. On the contrary, innovation and diffusion are interrelated and emerge out of the continuous interaction between groups of different entities (both private and public), with different objectives and various institutional forms. Science and technology are not completely independent entities, but in fact, they are very close and various linkages running in both directions;
- To be a successful participant in the technology race is a complex process that requires strong and persistent investments in education and R&D. Participate is by no means a problem of just choosing the best technology from the shelves. For a technology to be effectively appropriated and incorporated to the routines of a firm, it is necessary that the firm deploys major efforts at fully understanding the technology and assimilating it to every day work environment, which are costly and not always successful;
- Sometimes there is an opportunity to learn from the technological frontier and thereby to reduce the distance with respect to the frontier. On the other hand, if there are no internal efforts at learning, the technology gap will continue to increase and the potential for catching up will just become a lost opportunity. Concepts like learning by doing, learning by using and learning by interacting imply increasing returns. In literature (Katz, 1984; Narula, 2004; Bell, 2006; Porcile, 2009) these virtuous processes are neither automatic nor passive, but a function of investments in technological capabilities at the firm, the industry and the country levels. The domestic "absorptive capacity" of each country is crucial to define whether there the trajectory will be one of technological catching up or falling behind.
- The idea that participation in innovation is driven by internal efforts at learning implies that diffusion of technology occurs hand in hand with the adaptation and improvement of the original innovation, giving rise to a stream of incremental innovations. Such a stream represents a response to the specific technological and economic conditions in which diffusion takes place in each country. In effect, according to literature (Luiz, 2003), the

size of the market, the availability of human capital or intermediate inputs, the degree of sophistication of users and producers, are some of the country-specific factors that affect the speed and direction of technological diffusion. These factors vary widely across countries, as resources, technological capabilities and institutional environment vary;

- Technological opportunities are unevenly distributed across sectors (Dosi, 1995). The classical classification suggested by Pavitt (1993) points out that there is an inter-sectorial flow of technology and innovation in which some sectors play the leading role as sources of innovation, while others absorb the new technology embodied in capital or intermediate goods. The productive structure matters, as some productive structures produce more incentives to technical change (Cimoli and Porcile, 2009);

The intensity of learning depends strongly on the institutional framework that coordinates a vast set of objectives, rules and decisions of heterogeneous agents. It is important to stress that the interaction between institutions and learning shows increasing returns and path-dependency: virtuous process of catching up (falling behind) tend to be self-sustained and would not be reverted spontaneously. Therefore a key challenge for policy-makers is to devise a set of institutions that either brings about a virtuous cycle or at least stops a downward spiral (Cimoli and Porcile, 2009).

There are some main agents involved in the learning process.

First of all there are firms, whose survival and growth depends in many cases on technological innovation. In a world of Schumpeterian competition, which means that effort, assets, and fortunes should be continuously destroyed by innovation for displaced older technologies in order to make way for new ones, they will have to respond to or move ahead of its competitors with new products and process. The approach of these firms to innovation depends, as mentioned, on the sector to which they belong. But also depends on other factors that should be considered among the determinants of learning.

First factor is size: in the literature we can see the existence of thresholds and economies of scale that mean that larger firms innovate more than smaller firms.

Second factor is the property of the firm. However there is still ongoing debates about the foreign companies. Does the presence of foreign companies in other countries stimulate or hamper technological innovation. Some authors argue that they usually just imports technology with very little local effort. They use their own resources. But most of the time imports of foreign technology require adaptations that can possibly have an impact on local capabilities, both in the subsidiaries and in national competitors. Similarly, the presence of public firms in the industrial structure might be important and relevant, however there is no concrete answer if their influence is positive or negative. “Stick has two ends” can be an adequate expression, because public firms are more frequently used to develop local innovative capabilities, but on the other hand, public companies are more protected from competition, which reduces the stimuli for technological learning in the first place.

One more factor is „success breeds success” or “money makes more money”. Successful innovations and the performance of the companies will give better profits. Better profits or a higher rate of capacity utilization are likely to encourage more investment in R&D.

Along with the firms competing in the market, there are also private and public entities specialized in technological and scientific research. These entities only partially respond to market incentives and are less susceptive to competition. For instance, market success is not the main goal of an academic community if its performance is assessed in terms of its ability to further the scientific frontier, and this is mostly reflected by publications in various scientific journals. One more example can be given by activities in which the innovator cannot protect its intellectual property rights nor prevent innovation knowledge from freely diffusing to other entities. The complexity and diversity of objectives and rules that govern R&D and scientific research are reflecting the very nature of the learning process. This process can converge various science fields, interests and disciplines. Technological and scientific world has rules of its own, however at the same time this world is sensitive to the availability of funding and to market signals in various degrees (Dosi, 1995).

It is necessary to go further and be more precise as regards which specific entities are more relevant. Some authors have observed that universities are leading actors not only in “pure” scientific research but also in applied R&D in developing countries (Albuquerque, 2004). In these economies the productive structure tends to concentrate in commodities or low-tech manufactures, where the internal efforts deployed by both local and multinational firms are poor. In general the service sector is concentrated in low-tech services which act more as a safety net against open unemployment than as effective support to R&D in industrial and agricultural firms. Therefore firms do not have a dynamic network of suppliers of technology or technological services that could support or be a substitute of their own R&D.

1.7 The effects of cooperation between firms and universities on innovation

Conducting internal or external R&D is a significant factor characterizing the cooperation with universities. Investments into machinery and equipment as one of the innovative activities are hindering the cooperation with universities. According to the University of Tartu differences between firms that cooperate with home universities, compared to those cooperating with foreign universities exist. Firms cooperating with foreign universities are characterized by a higher level of internationalization, measured by an export and foreign ownership dummy.

The rationale behind university- industry cooperation is to create different linkages in order to exchange and transfer knowledge between the parties. The nature of knowledge has many dimensions (Nonaka and Takeuchi 1995). A distinction can be made between explicit and tacit knowledge, multidisciplinary versus mono-disciplinary or basic versus applied (Brennenraedts, 2006). In addition, universities can provide firms with graduates and faculty members to serve as employees and consultants or provide access to its facilities in order to effectively evolve the firm's capabilities. Through cooperation with universities, by taking part in curriculum development and delivery, industry can shape future employees. Access to highly trained students is one of the most acknowledged benefits from the industry side. Research results indicate that firms also value an enhanced image, which they get from collaborating with a prominent academic institution (Santoro and Chakrabarti 2002).

Depending on the specific needs, cooperation between universities and industry may take different forms. According to an extensive study among European universities, there are eight types of university-industry cooperation (Davey, 2011): *curriculum development and delivery, lifelong learning, student mobility, academic mobility, commercialization of R&D results, collaboration in R&D, entrepreneurship, and governance*.

University–industry interaction is not a single process of interaction, but covers a huge variety of relations, each being determined by partially different variables (Polt, 2001). The cooperation between universities and industry is embedded into policy framework conditions, which depend on the institutional and social setting within a society (e.g. regulations, promotion measures, incentive schemes). This gives the university–industry cooperation a strong path dependency.

Figure 2 shows how the nature of linkages will vary along with market conditions, demand characteristics, technology characteristics, and national and international industry networks.

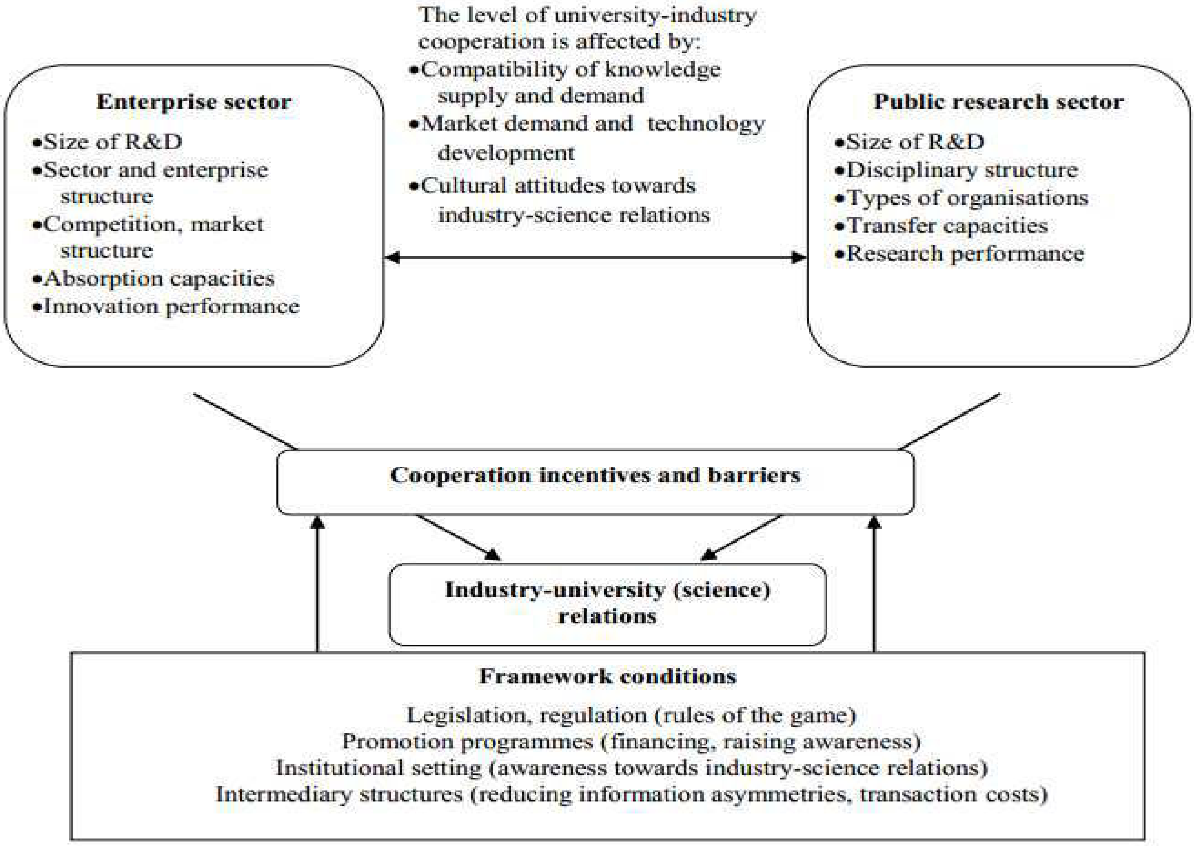

Fig. 2 The model for analyzing industry–university (science) relations (Polt, 2001)

The government tries to reduce the market failures by removing the barriers to knowledge transfer and cooperation between universities and industry. Polt (2001) defines different characteristics and aspects of firms, universities and the environment which influences the university-industry relations. The cooperation of enterprises and universities is affected by the cultural attitudes towards industry-science relations, compatibility of knowledge supply and demand, and market demand and technology development. From the enterprise sector side the cooperation is influenced by the size of R&D (relative size of research in different fields of technology), sector and enterprise structure (relevance of large corporations versus SMEs, relevance of foreign-owned firms), competition and market structure (e.g. degree of competition), absorption capacities (skills and innovation management capabilities of firms), and innovation performance (activities with respect to certain stages in the innovation cycle).

It is important to stress that the cooperation per se is not important, but the outcome of this cooperation or even more precisely the positive impact to the partners. This is especially true from the viewpoint of industry (Pertuzé, 2010). For enterprises, the cooperation partners can be also customers, suppliers or even competitors, whose role and impact on the firm's R&D is somewhat different. Firms take into account the benefits and costs when considering the cooperation with universities. The previous studies have revealed that outgoing spillovers (information flows going out from the enterprise) may reduce the wish for cooperation while incoming spillovers (external information flow useful for the innovation process of the enterprise) increase the attractiveness for cooperation. (Belderbos, 2004).

Cohen and Levinthal (1989) show that in the case of a firm's own R&D activities, the external knowledge is more important and effective for the innovation process. Investments in internal R&D increase the absorptive capacity of the firm and in this way as well the effectiveness of incoming information and knowledge (Belderbos, 2004).

Enterprises operate in the environment of intense global competition, rapid technological change, and short product life cycles (Elmuti, 2005). In the situation of rapid changes, limited resources, and knowledge, firms look for different external sources for advancing their knowledge and technology. The sources include customers, suppliers, competitors, public and private research organizations, and universities (Santoro and Chakrabarti 2002). Different partnerships may be used for different purposes. Customer cooperation is used more frequently in the case of bringing new products to the market or making product improvements. With supplier cooperation the aim is often to reduce costs. When cooperating with universities, the firms look for privileged access to new knowledge and also the possibility to increase the firm's scientists' understanding of scientific developments. (Belderbos, 2004) Universities are institutions outside of the industry and hence may possess unique and different knowledge, skills and resources than the other partners in the industry. Previous research has shown that university-industry cooperation has a positive influence on product innovation of the firm (Kang and Kang 2010). Therefore, the universities are especially valuable cooperation partners for the firms.

The determinants of the university-industry linkages have not been empirically studied much, although the literature on that topic is starting to grow. The size of the firm as the cooperation factor has been studied in various countries using different datasets, e.g. Tether (2002) (based on data for UK, CIS2). Tether (2002) argues that smaller enterprises have fewer internal resources and need more external knowledge, which means more cooperation partners. It is also stated in Tether's (2002) paper that cooperation with universities and other research organizations is positively related to the enterprise's size and the reason behind that is again resources – compared to smaller firms, larger ones have more internal resources to engage in that type of cooperation and larger firms are more likely aware of capabilities of universities. In contrast, Eom and Lee (2010) found that the size of an enterprise measured by the log of the average number of employees does not matter either in the case of university-industry cooperation or in the case of cooperation with government research institutes. However, all previously mentioned studies based on European countries' data reveal that size measured by the log of the number of employees is positively related to the probability to cooperate with universities.

Belonging to an enterprise group is considered to make it more likely to have cooperation partners. The reason behind that is the same as the one mentioned in the case of larger firms: they have more knowledge about the capabilities of universities (Tether 2002) and it is easier for them to access the information and establish contacts due to belonging to a network (Mohnen and Hoareau 2003). At the same time they have more internal resources, which on one hand give more opportunities for searching for a partner outside the firm, but on the other hand they might not need universities as knowledge sources as they can use knowledge from their own group (Tether 2002).

Absorptive capacity is seen as one of the determinants of university-industry cooperation. One possible proxy to use for absorptive capacity can be R&D intensity. Cohen and Levinthal (1989) assume that R&D plays an important role in increasing firm's absorptive capacity and therefore does not only create new knowledge, but helps the firm to exploit knowledge from external sources, for example universities. Mohnen and Hoareau (2003) argue that firms with a higher R&D intensity are more likely to cooperate with universities as they have the need to be connected to basic research. According to Fontana (2006) firms engaged in R&D activities, compared to those who do not conduct any R&D activities, rely more on scientific development. Fontana (2006) use the share of R&D employment to total employment as the indicator of R&D intensity. Miotti and Sachwald (2003) also found R&D to be positively related to the probability to cooperate with universities.

2. Research

2.1 Type of research

Empirical research in this paper will try to test the theory that industry companies can have benefits from collaborating with scientific institutions and that currently there are obstacles in the way for easy relationship between industry and science.

Empirical research methods can be divided into two categories:

- *Quantitative research methods*: such methods collect numerical data (data in the form of numbers) and analyze it using statistical methods;
- *Qualitative research methods*: such methods collect qualitative data (data in the form of text, images, sounds) drawn from observations, interviews and documentary evidence, and analyze it using qualitative data analysis methods.

In this case quantitative research method will be conducted.

The most common quantitative methods are:

- *Experiment*: apply a treatment, measure results (before and/or after);
- *Survey*: ask questions (face to face interview, telephone, mail, internet);
- *Historical data*: look for patterns in historical data (e.g. IT investment patterns).

We will be focused on survey and analysis of the correspondents answers.

According to the amount of industrial companies in the sector and the amount of innovative companies in the same sector, our survey was sent to 200 industrial companies that are working in these areas according to NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne). Surveys were anonymous:

- C22 - Manufacture of rubber and plastic products;
- C24 - Manufacture of basic metals;
- C25 - Manufacture of fabricated metal products, except machinery and equipment;
- C26 - Manufacture of computer, electronic and optical products;
- C27 - Manufacture of electrical equipment;
- C28 - Manufacture of machinery and equipment n.e.c.;
- C29 - Manufacture of motor vehicles, trailers and semi-trailers;
- C30 - Manufacture of other transport equipment.

From 200 survey forms 55 were answered which meant 27,5 % rate of return.

2.2 Value of innovation

The term innovation can be defined as something original and more effective and, as a consequence, new, that "breaks into" the market or society (Frankelius, P. 2009).

From literature we can see that Research and innovation are widely recognized as being the main drivers of economic growth and sustainable development. For example, on 18 June 2007 EU and Egypt signed the Research Development and Innovation (RDI) agreement with a grant of 11 million Euros to support research, development and innovation in Egypt.

According to our study of Lithuanian, Estonian and Latvian industrial business market we can see the value of innovation and research.

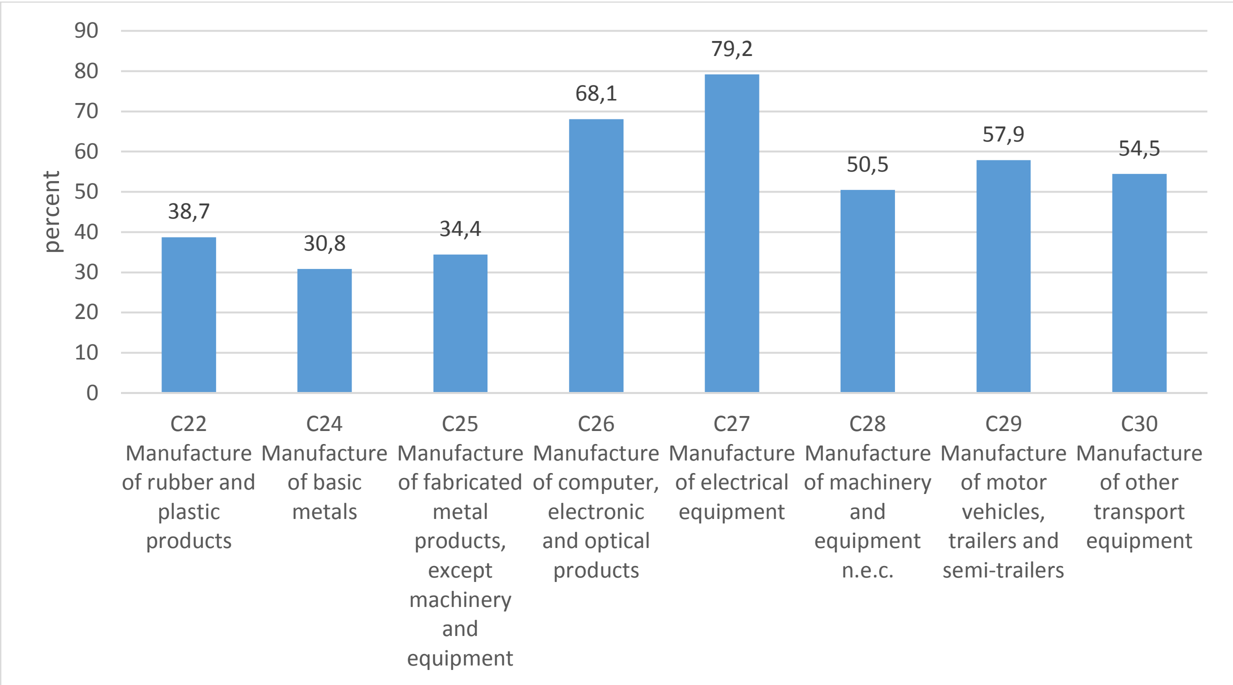

Fig. 3. Percentages of innovative industrial enterprises in Lithuania according to business areas by NACE. (stat.gov.lt)

For comparison we analyzed the total number of all innovative industrial companies in Lithuania, according to business area by NACE and total turnover of all innovative enterprises in comparison with all industrial enterprises in Lithuania.

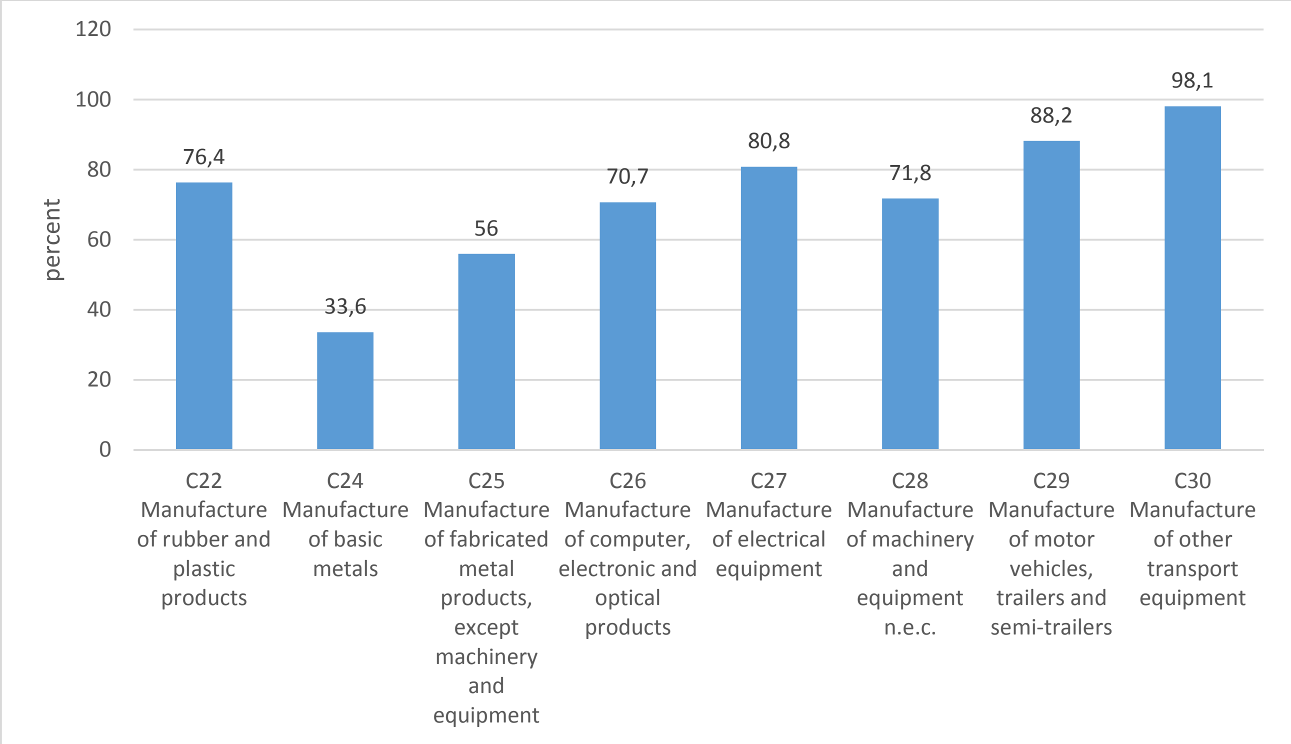

Fig. 4 Comparison of innovative industrial enterprises turnover with all industrial enterprises turnover in Lithuania according to business areas by NACE. (stat.gov.lt)

As we can see in the graphs in Fig 3 and Fig 4, in every case there is a positive impact of innovation for company turnover. Let's take C25 Manufacture of fabricated metal products, except machinery and equipment business area for example. There were only 34.4% innovative companies of all companies in C25 area. However those innovative companies were responsible for 56% of total turnover of all companies in that area. The same correlation is in other areas of industry to a lesser or higher extend. We can assume that in Lithuania Innovations in industry have a positive correlation to company annual turnover.

Similar results were found when analyzing Estonia and Latvia. In Latvia there were total 658 innovative enterprises in manufacturing sector. These companies amounted 19.6 % of total number of enterprises in 2008-2010. As we can see in Fig 5 there is even bigger correlation positive correlation of innovation and company turnover. Only 19.6 % of manufacturing companies managed to amount 46.7 % of total manufacturing sector turnover in 2008 and 55.4 % in 2010.

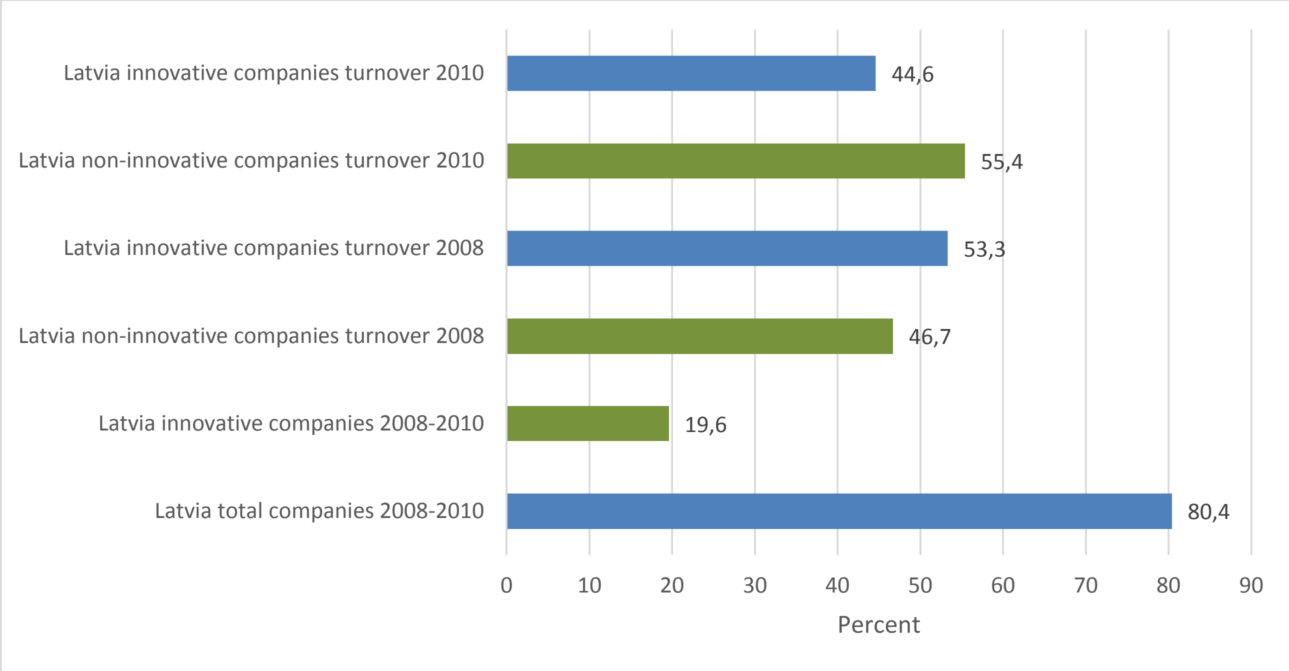

Fig. 5. Comparison of innovative industrial enterprises turnover with all industrial enterprises turnover in Latvia manufacturing sector. (csb.gov.lv)

We also analyzed the data of Estonian manufacturing sector. We found out that it had the exact same correlation. Lesser number of innovative companies produce more turnover than their counterpart's non-innovative companies.

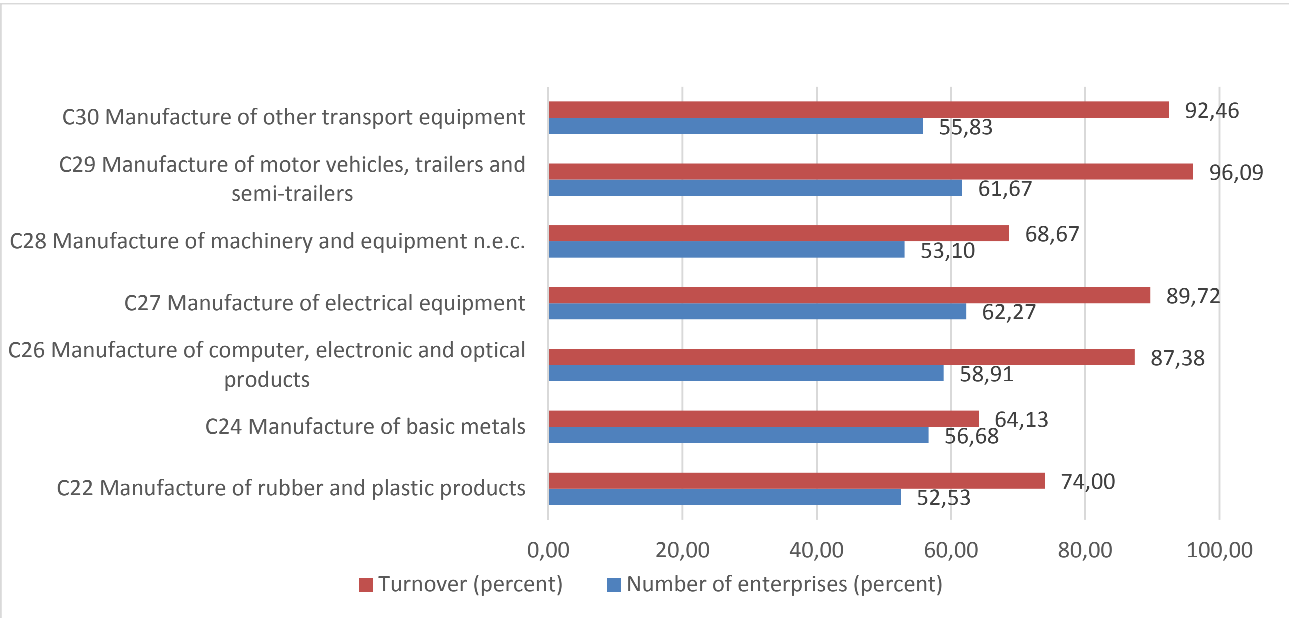

Fig. 6. Comparison of innovative industrial enterprises turnover with manufacturing enterprises number in Estonia manufacturing sector (2012). (pub.stat.ee)

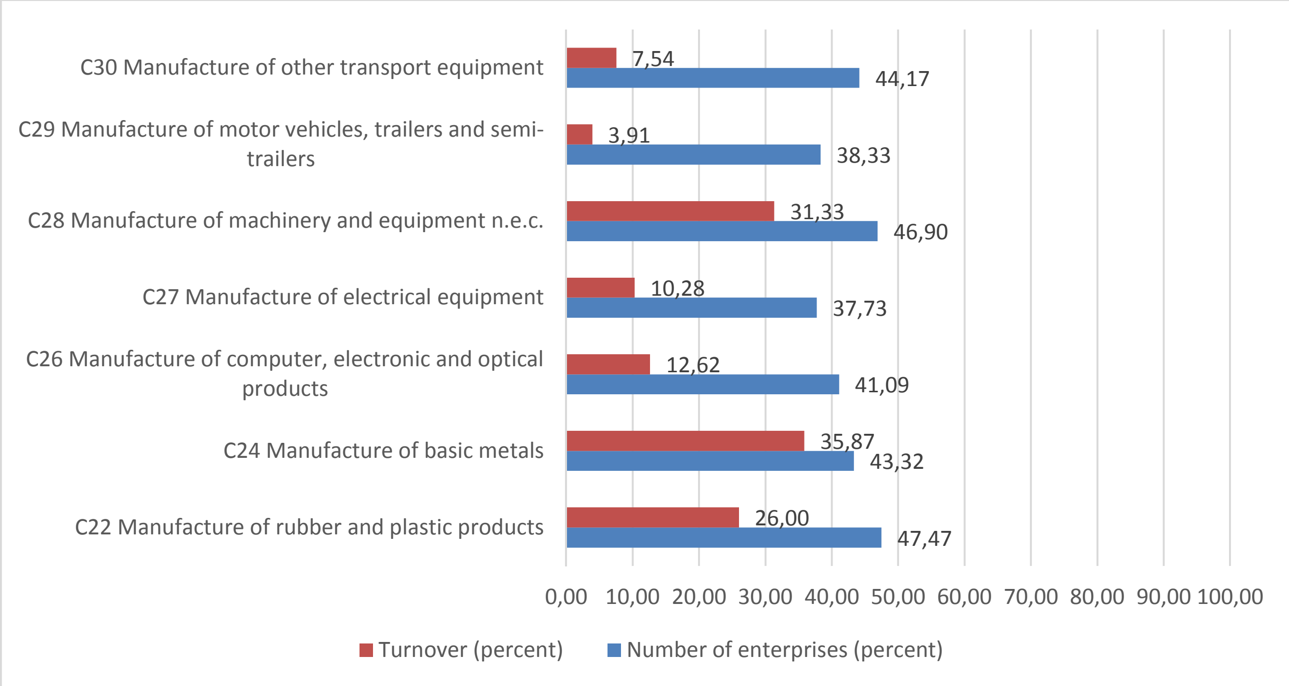

Fig. 7. Comparison of non-innovative industrial enterprises turnover with manufacturing enterprises number in Estonia manufacturing sector (2012). (pub.stat.ee)

In Figure 6 and Figure 7 we can see a comparison of innovative and non-innovative enterprises turnover and number of enterprises in 2012. Areas of business are stated as in NACE nomenclature.

In Estonia we can see the same signs as in Lithuania and Latvia. Innovative companies generate more turnover and have a larger part of the market then non-innovative companies.

2.2 Survey results and analysis

As mentioned before, survey was sent to 200 companies. Reply rate was 27.5% which generated 55 answered questionnaires. Due to some sensitive information in some questions the questionnaire was anonymous. Questionnaire form is added in Annexes of the document.

First questions were to gather general information about companies. All of the companies who answered were SME companies. There were 19 companies who had 31-60 employees, 15 companies – 11-30 employees and 16 – 60-100 employees.

The turnover of the companies was more varied. Turnover of all the companies is shown in Fig. 8. The most companies had 500k-3M Euros annual turnover.

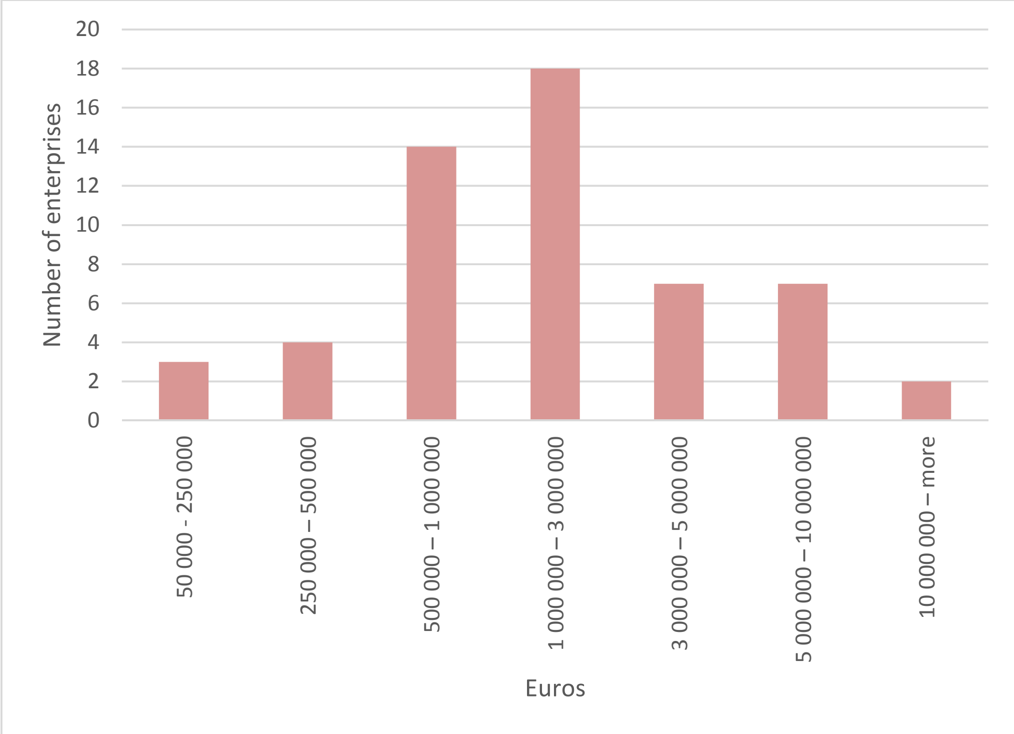

Fig. 8. Number of enterprises and their turnover

Next question was to determine how education level corresponds with the average salary of the workers in the company. Companies had to answer what is the average salary for workers who have only Middle school diploma, Bachelor degree, Master degree and Doctoral degree.

Answer data was evaluated using statistical methods and Average, Standard deviation, Variation coefficient was calculated. AVG of the lowest educational level was 348 EUR which was the lowest average of all. Also with the least amount of variation, which was 16.47%. All of the calculated variation coefficients calculated were in the range of 10-25% which means medium (allowable) variation.

Bachelor degree average salary was 453 EUR with 111.76 standard deviation and 24.67% variation.

Master degree average salary was 543 EUR with 121.31 standard deviation and 22.34% variation.

Doctoral degree average salary was 713 EUR with 164.85 standard deviation and 23.14% variation.

We can see that the higher education of the worker the higher salary he is paid.

When asked about university functions, industrial companies thought that the most important to them was "to provide academic and technical services to state and private enterprises through research training and consultancy activities in order to ensure an efficient transfer of necessary and appropriate technology for social and economic development at regional and national level“ with 216 points. Although other functions were evaluated very close (187 and 190 points).

Most of the companies (37) encounter problems when developing new products and are implementing new technology and agree (35) that collaborating with universities and other scientific institutions could help to solve arising problems.

When asked to rate (from 1 to 5, 1 being very easy, and 5 being very hard) the ease of access of information about scientific institutions capabilities, inventions and possible collaboration possibilities companies answers amounted to 201 points from max 275. In conjunction with the next question, “would a service that provides summary of initial information about scientific institutions and their possible services be helpful to find a suitable collaboration partner?” majority (38) of companies answered “Yes”.

Biggest reasons for not collaborating with universities, according to companies were “A university is unable to provide the service required for the price the company is willing to pay“– 18 points, „A university does not have the skill set or the facilities to meet the needs of the business“– 180 points, and „Hard to find in time an correct partner due to lack of condensed an understandable information about R&D capabilities of scientific institutions“– 172 points.

When asked if collaborating with scientific institutions could be beneficial to companies profitability 26 companies said “Yes”.

Accordingly they were asked what amount was spent on R&D and Innovations in 2012 and what was the increase (decrease) in company profitability. This was asked to understand the correlation between R&D expenditure and company profitability. 40 companies answered to this question. To calculate the correlation Microsoft Excel program was used.

In Figure 9 we can see the scatter of data.

Mean of expenditure was 108,49k EUR with 32.77 standard deviation and 30.21 variation which is more than 25% which is considerate medium variation, however due to the fact that there were a number of very different size and capability enterprises it is reasonable to assume that the amount of funds they could distribute to R&D was very varied.

Mean of profitability increase was 4.14% with 0.94 standard deviation and 22.56% variation coefficient which is within medium variation norms.

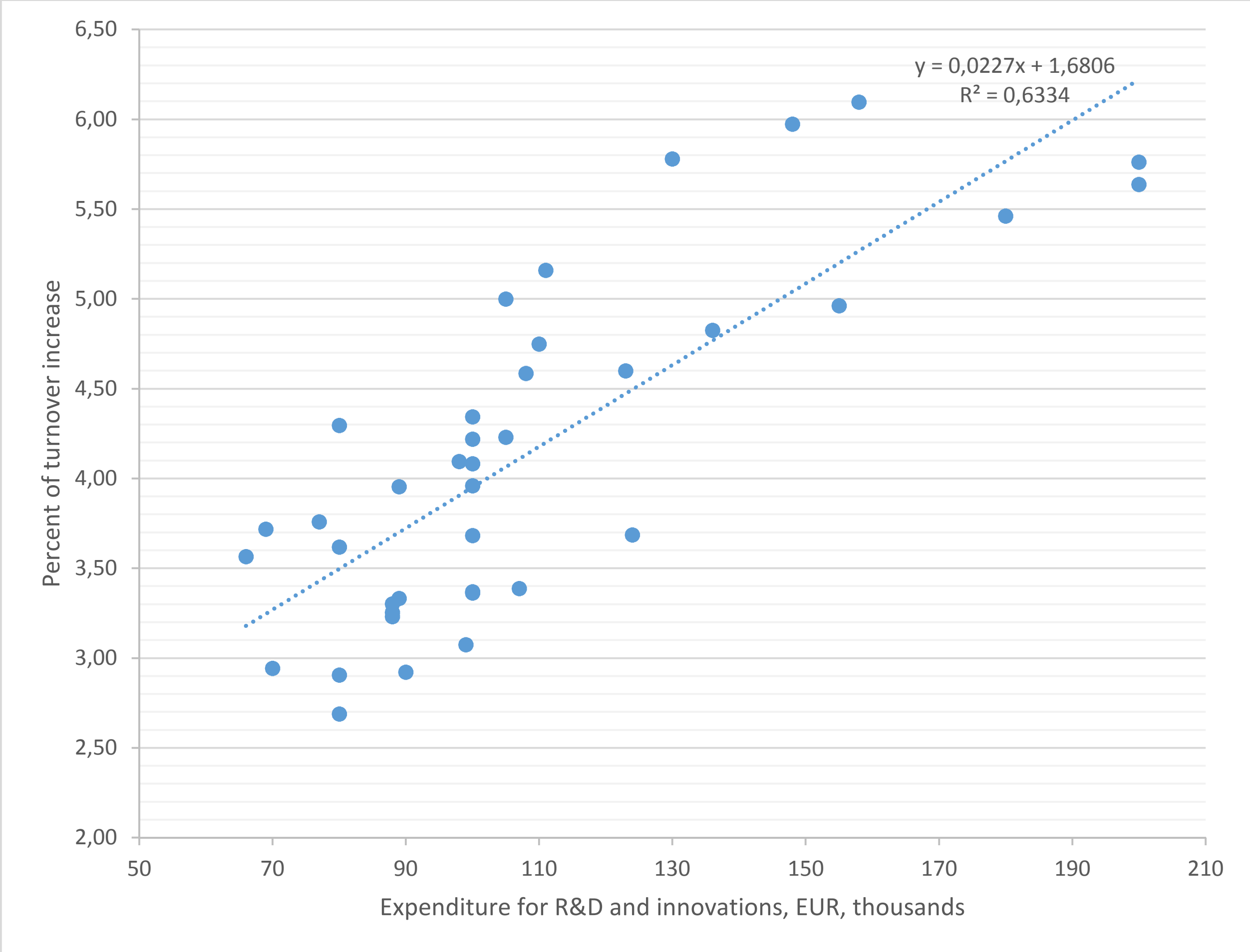

Fig. 9. Correlation between R&D and Innovation expenditure and increase in profitability.

Correlation coefficient R = R^2 = sqrt0.6334 = 0.79 which is high or strong correlation.

According to literature (Taylor. 1990) correlation coefficient interpretation these are the ranges of correlation coefficient:

- > 0.35 is generally considered to represent low or weak correlation;
- 0.36 to 0.67 modest or moderate correlation;
- 0.68 to 0.9 strong or high correlations;
- 1.0 perfect correlation.

According to our calculations correlation between R&D and Innovation expenditure and increase in profitability is highly correlating.

When asked if companies believe that the partnership between science and industry should always be measured by artificial metrics to value the relationship 19 companies said "Yes" and 25 said "Maybe".

Also only 9 companies answered “Yes” to a question if university teachers have a good understanding about the business world. 15 said “No” and majority (31) said “Yes, but not enough”.

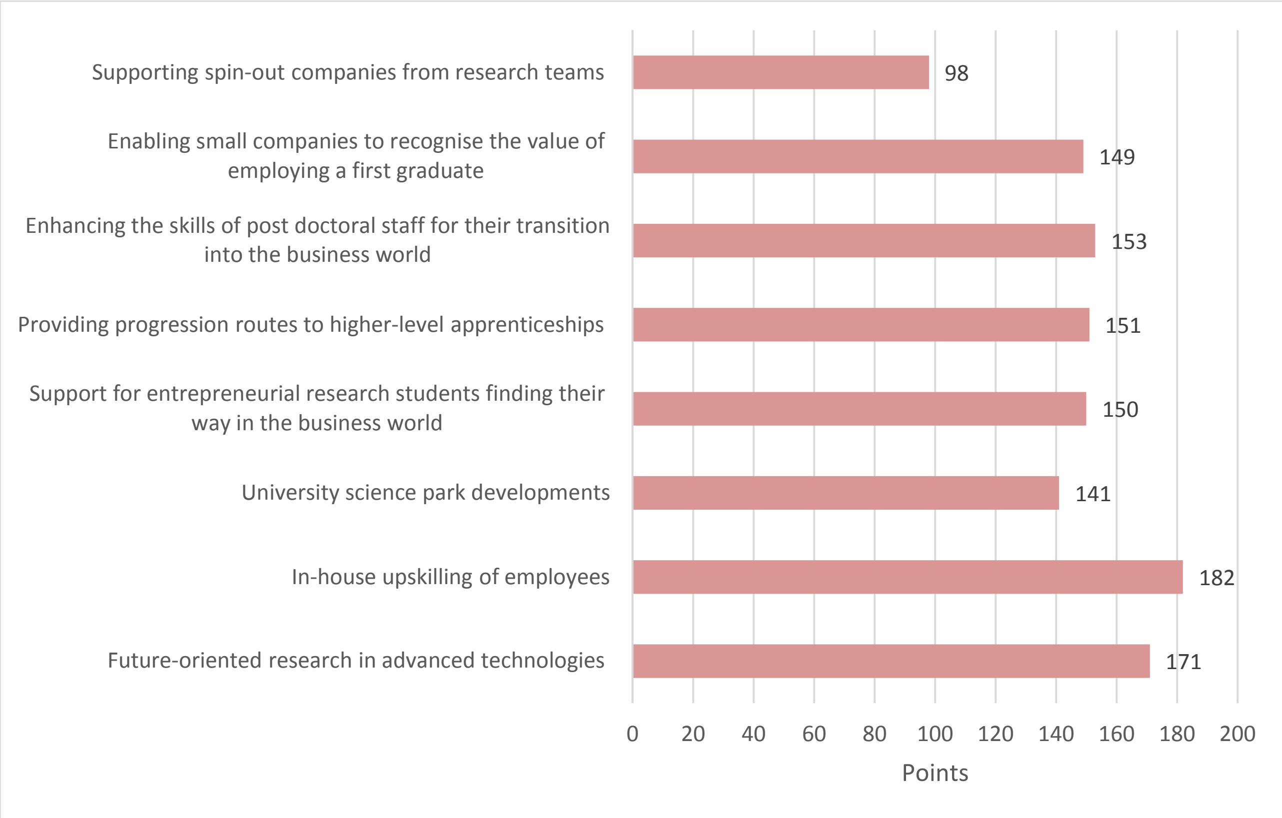

Fig. 10 Domains of collaboration and their importance.

The last question was to understand which collaboration domain is the most important to companies. Analyzing the results it is apparent that importance is given to all of the domains with the least amount to spin-out companies and the most to In-house upskilling of employees.

2.3 Summary of results

From the results analysis it is understood that innovation and R&D have a positive impact on company profitability. In multinational comparison we can see that innovative companies in Lithuania, Latvia and Estonia are generating relatively more turnover than non-innovative companies in industrial manufacturing sector.

Most of the companies agree that cooperation between science and industry can be beneficial and our calculations and statistical data agree that it is true. Although companies seems to have difficulty starting fruitful relationships with scientific institutions.

First of, the mission and goals are not always compatible between science and industry. Main objective of Universities is to produce graduates with high-level professional skills and moral integrity to meet the need for human resources. Companies agreed that this is important but they saw that providing academic and technical services to state and private enterprises through research training and consultancy activities in order to ensure an efficient transfer of necessary and appropriate technology for social and economic development at regional and national level is more important.

Most of the companies encountered problems when developing new products or implementing new technology and agreed that collaboration could help to solve those problems.

Main problems, according to companies, that influences the lack of collaborations were:

- **Financial**. A university is unable to provide the service required for the price the company is willing to pay;
- **Technological**. A university does not have the skill set or the facilities to meet the needs of the business;
- **Informational**. Hard to find in time a correct partner due to lack of condensed an understandable information about R&D capabilities of scientific institutions.

Evaluating the results we can see that companies need to be encouraged to collaborate with Universities and other scientific institutions because there are certain benefits to it. Considering there are more possible barriers to hinder future collaboration, we talked about 3 top ones.

This paper will present a possible solution to one of the problems that have a negative impact on science-industry collaboration. The problem that will be addressed is **Informational**. In this paper a conceptual model and implementation of scientific institution database with classificators that that makes information easy to find and respond to will be presented. There will be two classification trees. One, official approved by government which includes fields of study and second, which is tailor made by assessing the good practice of one of the best research and development institutes in the Europe and maybe the world.

3. Concept model, implementation and further development

3.1 Basic model

Taken as a whole, University-Industry cooperation is a bidirectional beneficial mechanism where universities get benefits from industry including financial and technological incentives. On return, Industry can enjoy cheap R&D labor with latest equipped labs and latest knowledgeable researchers.

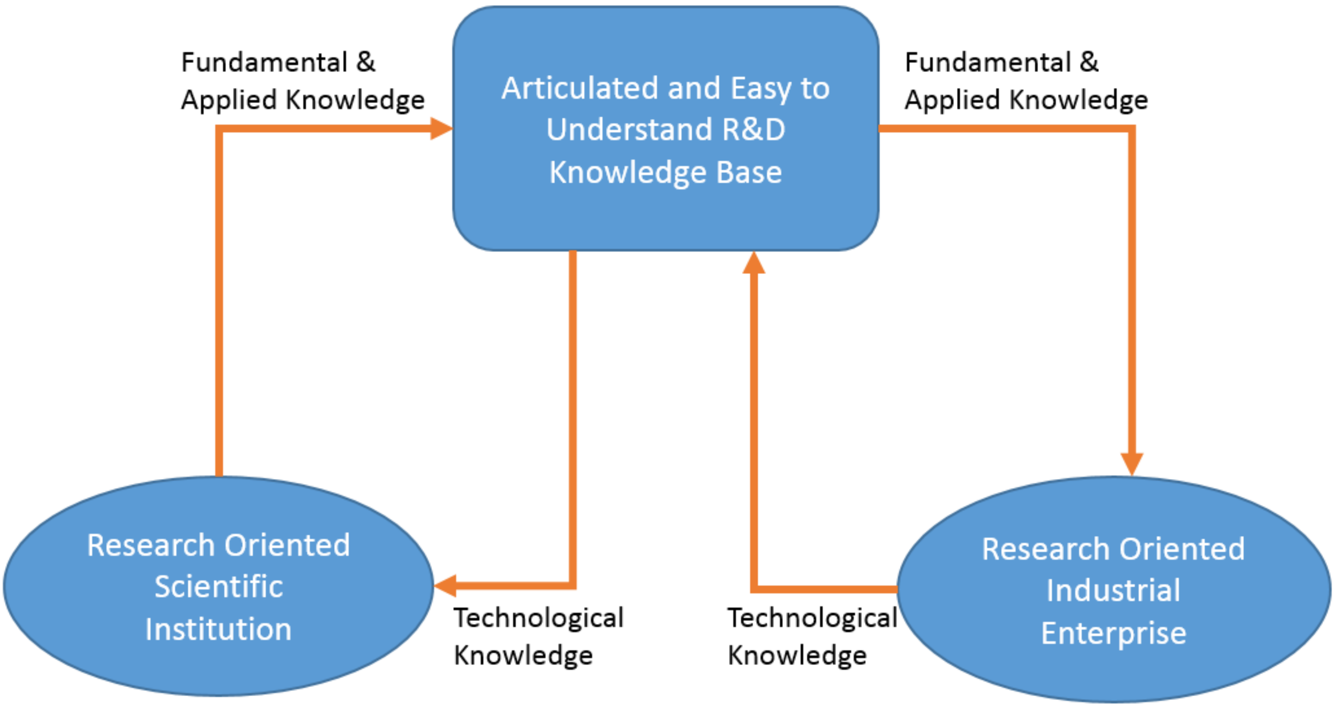

Fig. 11 2-way mechanism for University-Industry collaboration.

In Figure 11 a basic model for University-Industry collaboration where both partners can establish an articulated R&D environment for successful execution of R&D projects is shown. Taking under consideration of all factors for University-Industry collaboration sustainability and barriers to this sustainability, desired results can be achieved through 2-way collaborations.

First stage is the complete database of all current and future R&D services of all scientific institutions. The hard part is to classify all services in a manner that a non-academic person could easily find a service he is looking for that would solve his problem. The right classification trees and optimized search engines must be used.

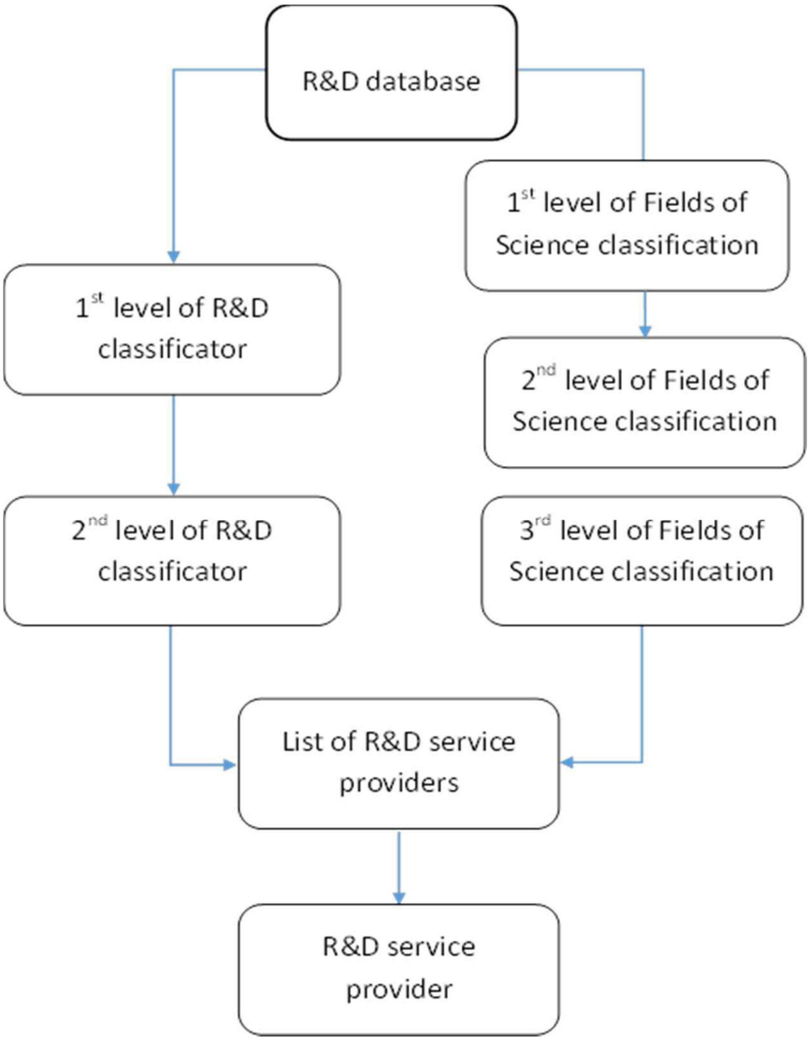

Fig. 12 Conceptual scheme of R&D database

In Figure 12 the Conceptual scheme of R&D database is shown. To structure all data about R&D service providers and possible collaborators with industrial companies, two main classification pathways are presented.

First one is classification according to the Fields of Science and the second one is Classification by a custom made classificator of R&D services using good practices of experienced Scientific Institutes.

3.2 Classification system for R&D database by Fields of sciences

Current fields of sciences will be used as a classification model. R&D services will be assigned to their respective field of sciences to have a uniform and easy to access database of all R&D services.

Fields of Sciences, Council, consists of three levels of content. First level is consisted of these parts, according to current approved documentation by Lithuanian Science:

- Natural Sciences;
- Engineering and Technologies;
- Medical and Health Sciences;
- Agricultural Sciences;
- Social sciences;
- Humanities.

These fields are detailed in the Frascati Manual. However, since this paper is concerned only with industrial engineering companies, Medical and Health Sciences, Agricultural Sciences and Humanities fields will not be addressed to. Attention will be directed to Natural Sciences, Engineering and Technologies and Social sciences fields and all the included subfields.

In the table below an excerpt of FoS (Fields of Sciences) classificator is shown. Full table can be found in the Annexes.

Table 1 Excerpt of FoS (Fields of Sciences) classificator.

1.	Natural Sciences	**1.1**	Mathematics	**1.1.1**	Pure mathematics, Applied mathematics
				1.1.2	Statistics and probability
		1.2	Computer and information sciences	**1.2.1**	Computer sciences, information science
				1.2.2	Bioinformatics
		1.3	Physical sciences	**1.3.1**	Atomic, molecular and chemical physics
				1.3.2	Condensed matter physics
				1.3.3	Particles and fields physics
				1.3.4	Nuclear physics
				1.3.5	Fluids and plasma physics
				1.3.6	Optics, Acoustics
...	**...**	**...**	**...**	**...**	...

All three levels can be clearly seen. Using this path of data sorting, biggest attention is given to the activities of the scientific institutions and assigning various third level FoS classificator entries that correspond to those activities. One institution can be assigned more than one entry.

3.3 Classification system for R&D database by R&D services

R&D service classificator is based on the good European technology centers experiences and it is using non-standard R&D (Research, Development and Innovation) classification schemes that reflect the actual services provided by the R&D for existing businesses. This classification consists of two main levels.

Table 2 Excerpt of R&D services classificator.

1	Energy	**1.1**	Flow simulation and thermal calculations
		1.2	Burning stoves, Oil-fired furnace and boilers
2	Industrial measurements	**2.1**	Materials characterization
		2.2	Calibration and metrology
3	Surface technology	**3.1**	Micro technology and surface analysis
		3.2	Nano and Micro process technology
		3.3	Nano materials
		3.4	Multifunctional surfaces
		3.5	Surface treatment
		3.6	Sol-gel surface technology
...	**...**	**...**	...

Both levels can be clearly seen. Full classificator can be found in the Annexes at the end of the paper.

Using this path of data sorting, biggest attention is given to the possible R&D services that a certain scientific institution can provide. To every institution a certain number of 2nd level classificator entries can be assigned that correspond to those services.

3.4 Questionnaire for gathering and validation of data

A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. Although they are often designed for statistical analysis of the responses, this is not always the case.

Questionnaires have advantages over some other types of surveys in that they are cheap, do not require as much effort from the questioner as verbal or telephone surveys, and often have standardized answers that make it simple to compile data.

In this model questionnaires will be used to gather data that is not accessible by simple means using public access and to validate current information that was gathered using public access.

LOGO	**Name**
Contacts	**Additional information**
CEO	Registration code
Address	VAT
Phone	Employees
Fax	Foundation
E-mail	Projects turnover (mln. EUR)
Website	Subdivisions
Fields of science	
R&D classification	
R&D services	
Projects	
Description about the institution	

Fig. 13 Questionnaire for scientific institutions

Usually, a questionnaire consists of a number of questions that the respondent has to answer in a set format. A distinction is made between open-ended and closed-ended questions. An open-ended question asks the respondent to formulate his own answer, whereas a closed-ended question has the respondent pick an answer from a given number of options. The response options for a closed-ended question should be exhaustive and mutually exclusive.

In this questionnaire, which is shown in Figure 13, all needed information about the scientific institution is gathered. After gathering enough information from about 50 institutions, the R&D service provider identity cards are going to be prepared. Each of these cards represents one institution with all needed information to start possible future collaboration activities.

3.5 Concept of R&D service provider identification card

Bellow in Figure 14 conceptual identification card of R&D service provider is shown. Earlier, gathering information using questionnaires and public sources, will be concentrated into fields that are shown in the concept card.

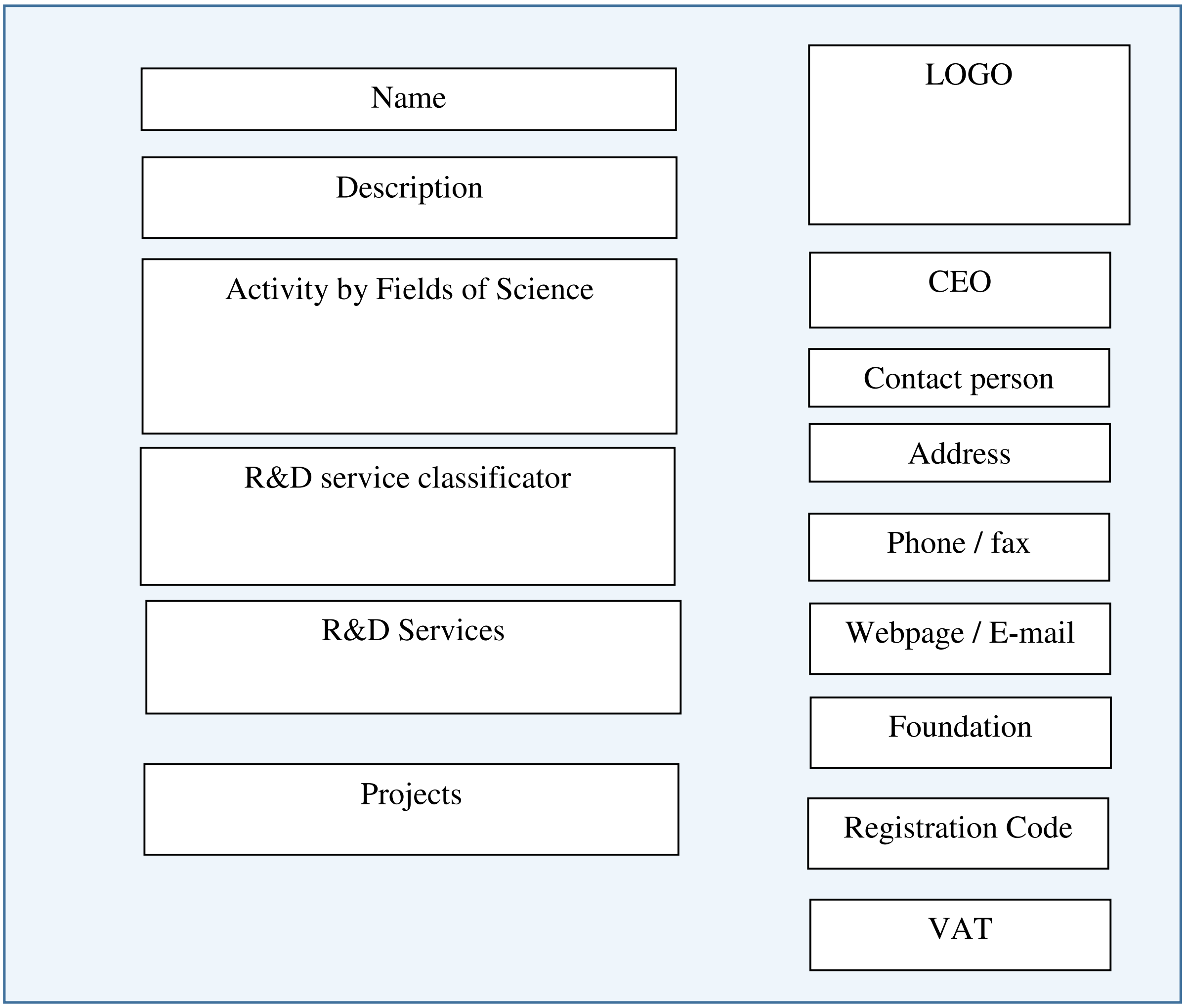

Fig. 14 Concept of identification card in the database

These identity cards are essential for creation of structured database that can be easily used by anyone who wishes to find useful information about R&D service providers and to acquire contacts for future collaboration efforts.

3.6 Implementation of the model

In this chapter the current implementation of the Collaboration model will be explained in more detail. The core concept of Database of R&D service providers and the engineering industry companies can be found at www.vipkc.lt. Model was implemented by the Engineering Industries Association of Lithuania (LINRPA). Database model was one of the results of the project that was funded by EU. Project name was R&D network integration into manufacturing of the future. My contribution to the project was creating the model of classifying R&D services and institutions to make it more easily understandable and searchable to non-academic people.

This model will focus on the scientific institution side of the database and their classification inside.

There are two ways to search for information:

- To use the classificators (where info is classified by Fields of sciences and R&D services);
- To use the integrated advanced search tool.

On the first level of database (Figure 15) two buttons can be seen. Point of interest is the green button named „R&D Service Providers". This is the database of Lithuanian scientific institutions that can provide some sort of R&D service.

Fig. 15 First level of database

After clicking on the green button the second layer of the database is shown (Fig. 16).

R&D service providers are classified by the fields of science and by the custom R&D classificator. If you are interested in the scientific institutions that focus in the specific fields of science, use the Fields of science classification. If you are interested in the scientific institutions with specific R&D services, use the R&D classification.

12 buttons represent the first level of R&D Classification.

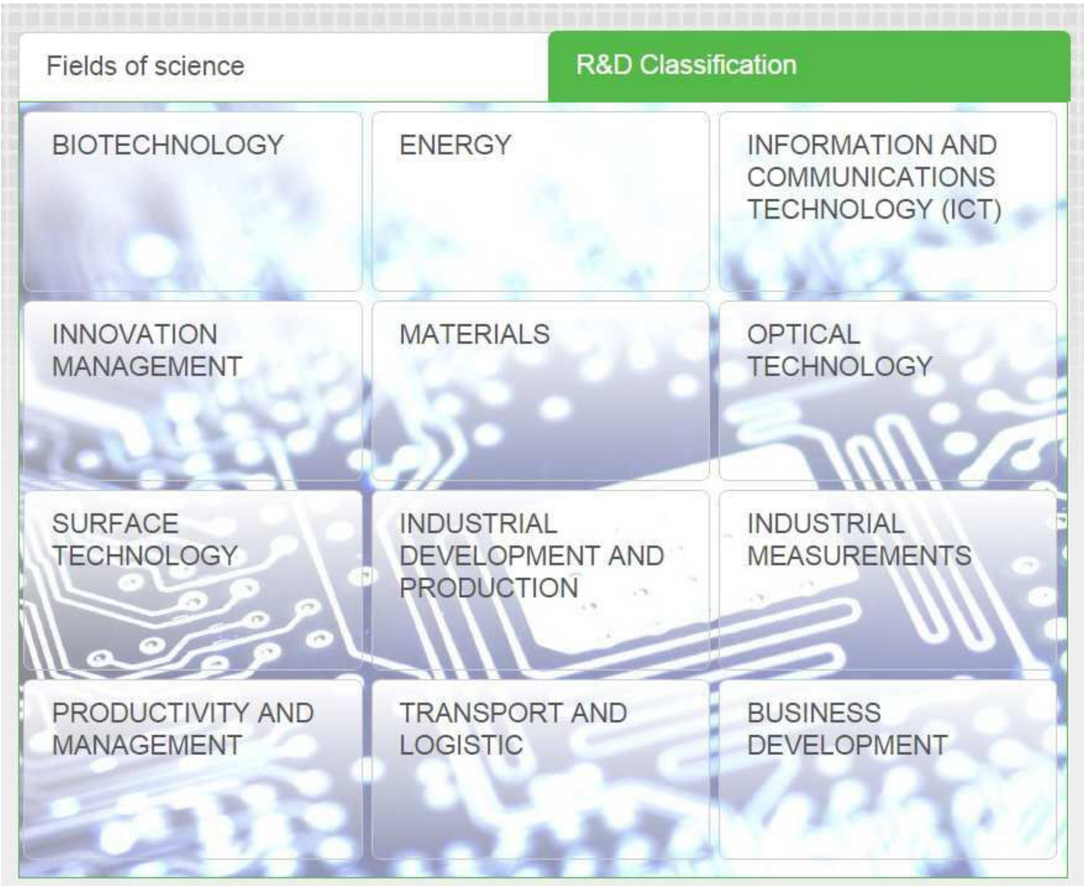

Fig. 16 Second level of database (R&D service providers)

Names of the first classification level are distilled from the good practice of one of the oldest and biggest Technological institute in the world, DTI (Danish Technological Institute) and VTT (Technical Research Centre of Finland), SWEREA (Swedish Research Group).

The point was to understand the current R&D services that are already circulating in the market of other countries that have experience. Using the information from these institutes, the alpha version of the classificatory was devised. After that, using logical reasoning and analysis of Lithuanian market the classification that was more suitable for our country was created.

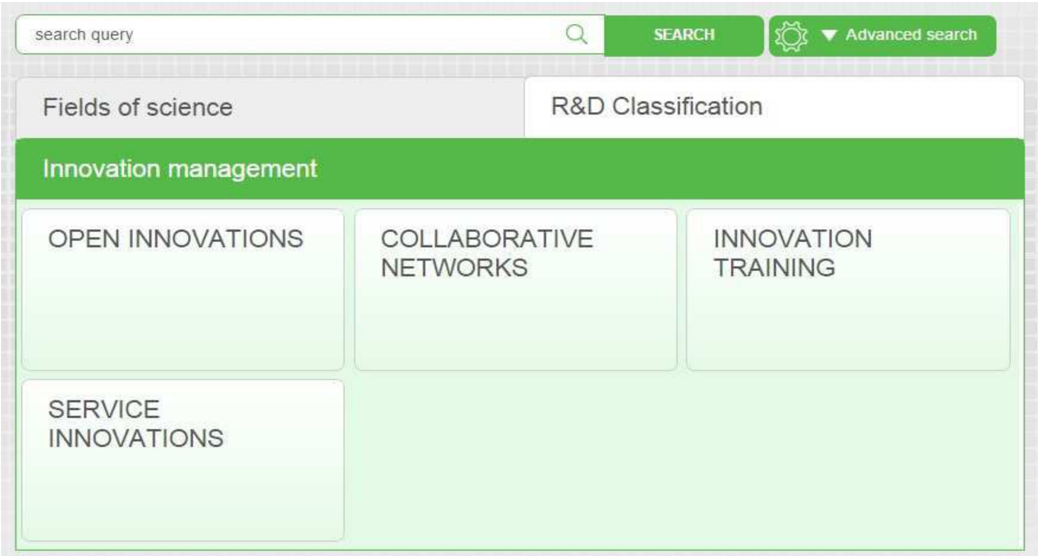

Fig. 17 Third level of database (R&D service providers)

Going further the Innovation management is chosen. In Fig. 17 the second level of the R&D service classificator can be seen.

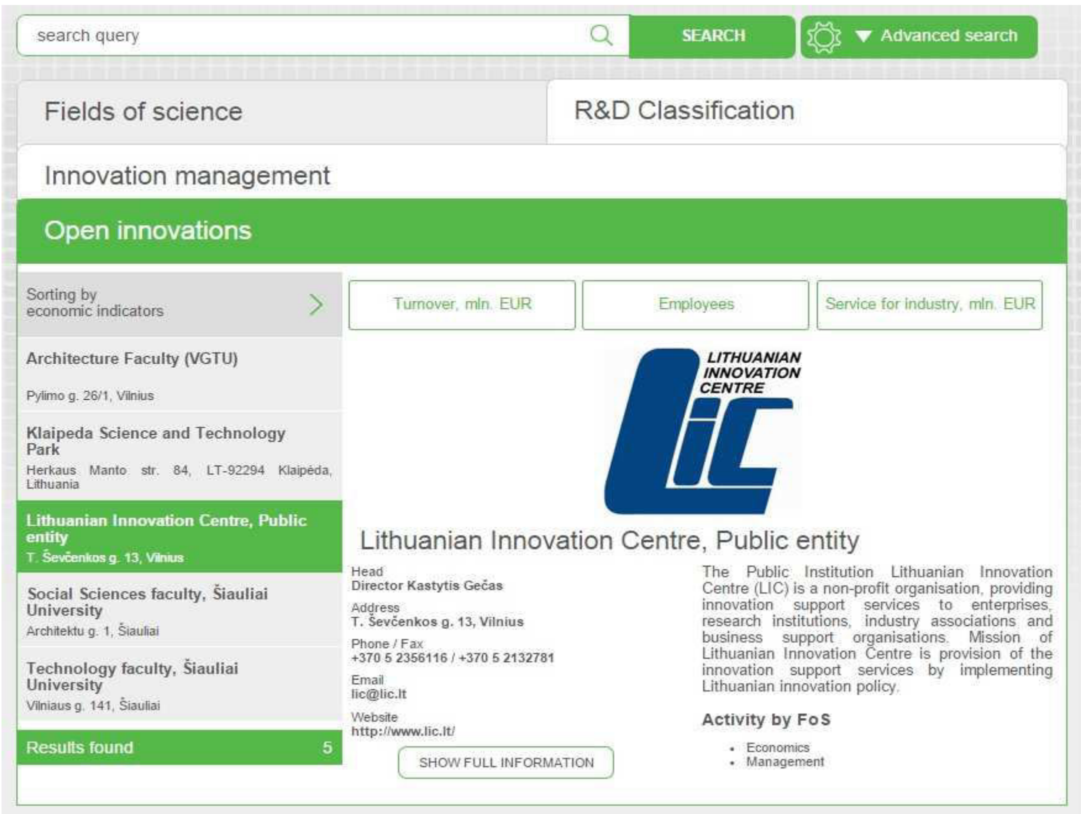

Fig. 18 R&D service provider list (Company in the picture is an example of data presentation)

Information cards are comprised of information that is initially gathered using publicly accessible channels. After the initial information input to the database is finished institutions can check their informational cards and see if the information is correct. If they find mistakes they can contact the administrator or fill out the form which is accessible in the database.

This database brings together the competencies of R&D service providers operating in Lithuania and systematizes them in a way that is understandable to producers and researchers.

Database acts as an intermediary between engineering industry companies/service recipients and R&D service providers.

3.7 Implementation of the model (2)

In the last chapter only one side of the database was shown. The scientific institutions side. However, this database consists of two parts. Scientific institutions and Engineering industry companies. Even though this paper is more concentrated on the scientific institutions portion of database, engineering companies side must be discussed and presented also. This part was created by other project participants that were included into working in R&D network integration into manufacturing of the future project.

First level of the database corresponds with Figure 15.

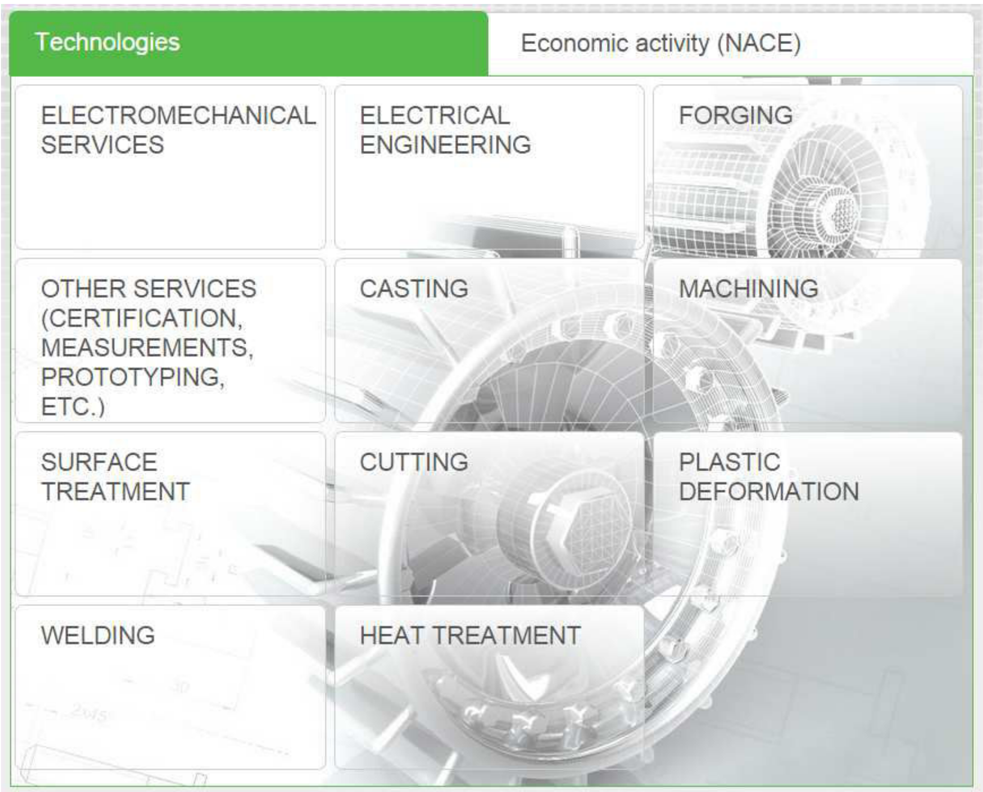

Fig. 19 Second level of database (Engineering companies)

Engineering Industry companies of Lithuania can be found in this part of the database. These companies are classified by technologies and by economic activity (NACE). If you are interested in the companies that use specific methods or technologies for manufacturing, you should use the Technologies classification. If you are interested in companies with specific product groups and general economic activities, you should use the NACE classification.

In Figure 19 technologies classification is highlighted. This classification was made using logical reasoning when analyzing possible technologies in engineering sciences. The final list was distilled in Engineering Industries Association of Lithuania (LINPRA) and then used in the database. Currently LINPRA is using classificated database of about 450-500 industrial engineering companies. However that classification only has one level. This can make harder for easy access and easy navigation through the database.

Fig. 20 Third level of database (Engineering companies)

This database is using two levels of technology classifications. This is more intuitive and easier way to find an industrial company that you need according the technologies that they use.

As it is seen in Figure 20 every “surface” level that was shown in Figure 19 has one more layer of more concrete technologies. Further down we can find a list of engineering industry companies that are using the corresponding technologies.

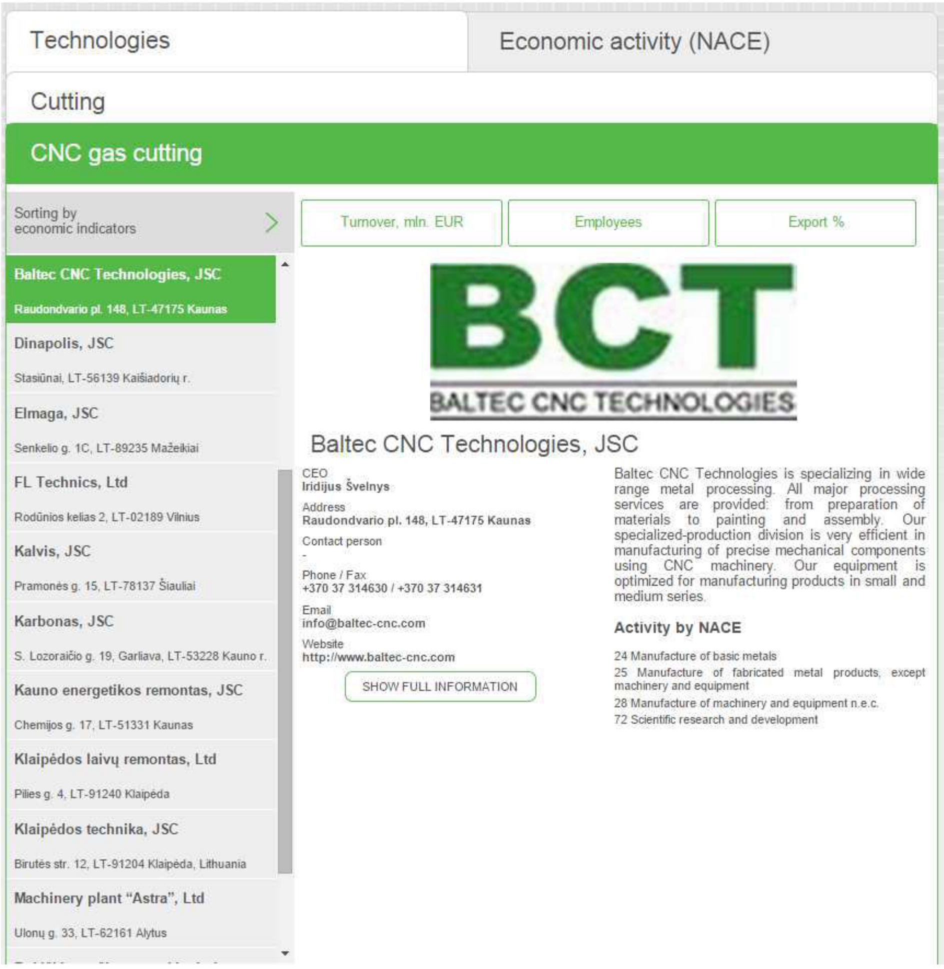

Fig. 21 Engineering industry companies list (Company in the picture is an example of data presentation)

Using the generated list in the same manner depicted earlier for scientific institutions, users can find information about specific companies. Information is depicted in a similar manner as the scientific institutions information.

The end result of this database is not only to improve collaboration and relationship between engineering industry and scientific institutions, but also to help to find possible future partners. Companies can find similar companies to collaborate on big projects and research institutions can share knowledge and can collaborate with other institutions for solving science problems and researching new technologies that otherwise would be impossible to do alone.

3.8 Possible future expansion of the model

First and initial concept of the model is only directed locally. Only Lithuanian companies and institutions can be found on the database. Real possible expansion can be done integrating all Baltic States into the model. After that – Europe.

Current goal is to make engineering industry companies and scientific institutions to collaborate with one another. Basically it means two different economic activities collaboration. NACE M72 which is scientific research and development and engineering industries that are considered NACE C22-C30.

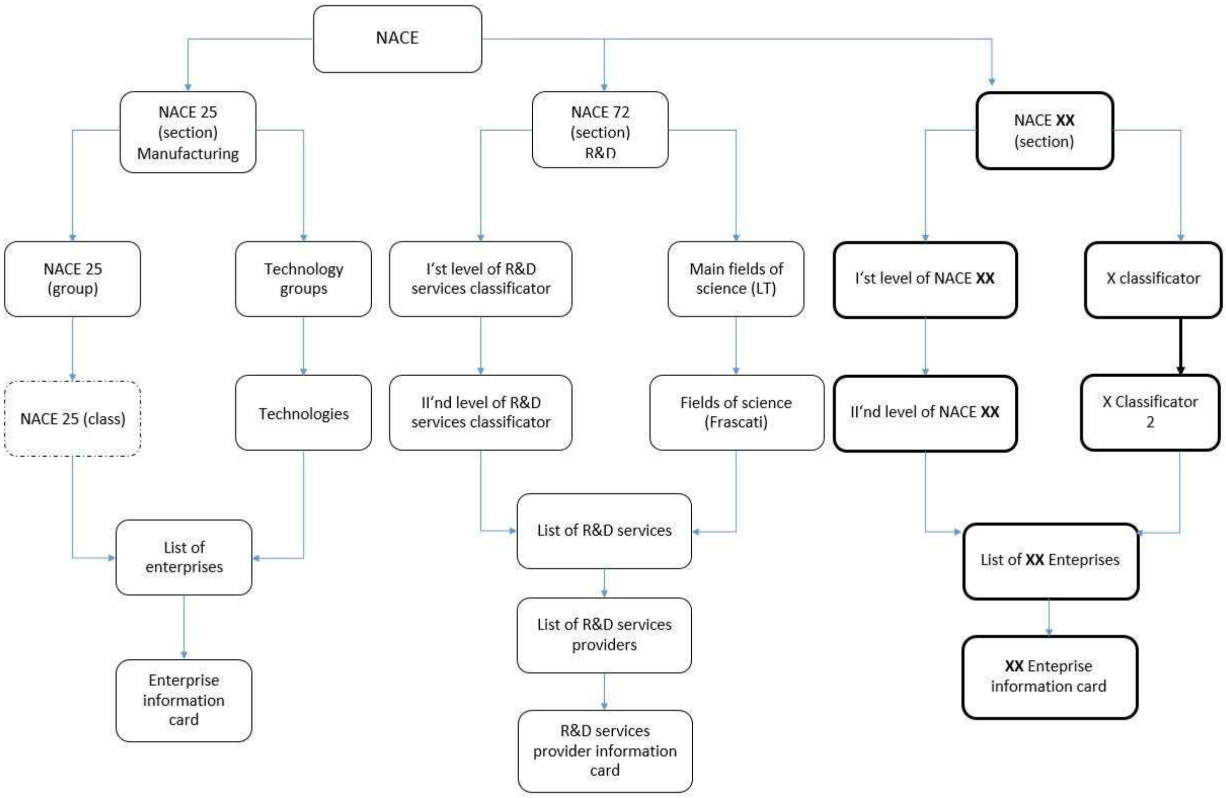

Fig. 22 Possible expansion of the model

In reality, this model can be expanded almost indefinitely to every economic activity there is. However, to continue the same concept of classification, every economic activity will have to have independent and custom classificator for easy access and usage.

As it is seen in Figure 22 the model can be horizontally expanded almost indefinitely. All problems are on the vertical level, custom classificators. For every horizontal part of the model a team of experts must be assembled. These experts will make the classificators for each part.

3.9 Model integration with R&D project financing instruments

There are four major financing instruments in Europe for R&D projects. These projects benefit from partnerships.

Industrial companies should collaborate with R&D institutions so that projects can get financing more easily. It is possible to integrate the major R&D project financing instruments into the Concept model. Using that, companies and institutions can filter all database entries to such detail that only enterprises that are interested into getting financing for a project using a specific instrument. Currently, as mentioned above, there are 4 major instruments:

- Horizon 2020;
- COSME;
- EUREKA;
- EUROSTARS.

Horizon 2020. Horizon 2020 is the biggest EU Research and Innovation program ever with nearly €80 billion of funding available over 7 years (2014 to 2020) – in addition to the private investment that this money will attract. It promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation.

COSME. COSME is the EU program for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (SMEs) running from 2014 to 2020 with a planned budget of €2.3bn. COSME aims to make it easier for small and medium-sized enterprises (SMEs) to access finance in all phases of their lifecycle – creation, expansion, or business transfer.

EUREKA. EUREKA is an intergovernmental organization for market-driven industrial R&D. It is a decentralized network facilitating the coordination of national funding on innovation aiming to boost the productivity & competitiveness of European industries. The network integrates over 40 pan-European economies, but also includes Israel, South Korea, and Canada.

EUROSTARS. The Eurostars Program is a joint program between EUREKA and the European Commission and the first European funding and support program to be specifically dedicated to research-performing SMEs. Eurostars stimulates them to lead international collaborative research and innovation projects by easing access to support and funding. Eurostars projects are collaborative, meaning they must involve at least two participants (legal entities) from two different Eurostars participating countries. In addition, the main participant must be a research-performing SME from one of these countries.

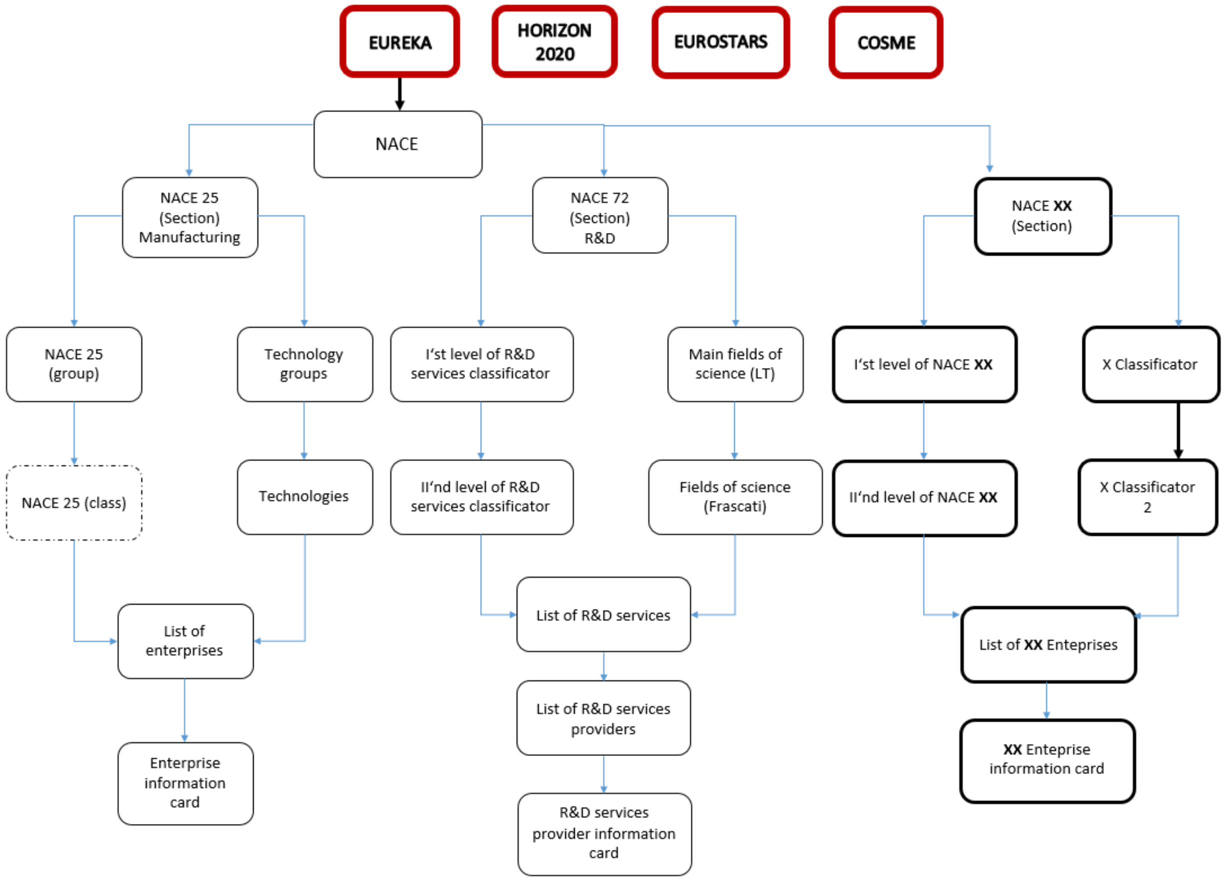

Fig. 23 Model expansion using main R&D project financing instruments

We can see that, for example, EUROSTARS projects must involve at least two participants. That's where the model that is depicted in this paper can be very useful. Enterprises can easily find each other and exchange contact information for future collaboration projects.

To make this possible an additional level must be added to the current concept model as seen in Figure 23.

Additional level provides more complexity but also provides more concrete and relevant data for the user. Also this can provide easier access to international collaboration which is a lot harder to accomplish than a local collaboration.

During international collaboration knowledge transfer and dissemination can be achieved on a higher level and a larger territory can be affected by positive impact of R&D collaboration, which in return incentivizes the local government and EU to further develop R&D financing instruments and programs.

Conclusion

1. Research and development is one of the means by which business can experience future growth by developing new products or processes to improve and expand their operations.

Research and Development is characterized by high levels of uncertainty. In addition, cumulativeness, complicated information and path-dependency are all factors that imply that pure market mechanisms will not produce the optimum amount of innovation and learning.

Private firms invest very little in R&D and the development of the network of technological services is rather weak, universities should play a particularly significant role. Universities concentrate large part of total research, and therefore it is crucial to develop mechanisms of cooperation that approximates the knowledge generated by the universities to the needs of the firms competing in the market.

2. First innovative companies data was analyzed. Lithuanian, Estonian and Latvian industrial innovative enterprises were compared with their non-innovative counterparts. Results implied that innovative companies in every industrial field were outperforming non-innovative enterprises. Innovative companies turnover for the number of companies were greater than non-innovative in all three Baltic countries. Further research was conducted using qualitative research methods. In this case a questionnaire was developed and the questions were tailored to understand the need and difficulties for collaborating with scientific institutions. Most of the companies encountered problems when developing new products or implementing new technology and agreed that collaboration could help to solve those problems.

Main problems, according to companies, that influences the lack of collaborations were Financial, Technological and Informational. The questionnaire was sent to 200 companies with the rate of return of 27,5%.

Biggest reasons for not collaborating with universities, according to companies were “A university is unable to provide the service required for the price the company is willing to pay“– 18 points, „A university does not have the skill set or the facilities to meet the needs of the business“, and „Hard to find in time an correct partner due to lack of condensed an understandable information about R&D capabilities of scientific institutions“.

Accordingly companies were asked what amount was spent on R&D and Innovations and what was the increase (decrease) in company profitability.

After processing the data using statistical methods, mean of profitability increase was calculated 4.14% with 0.94 standard deviation and 22.56% variation coefficient which is within medium variation norms.

Correlation coefficient (R=0,79) showed high/strong correlation.

3. One of the main collaboration problems that were found during the research stage was Informational. In this paper, an empirical model, in the shape of database, is offered for stimulating innovation collaboration between science institutions and industrial firms.

Purpose of this database is to provide structured and understandable information for manufacturers and researchers about the R&D services and innovations that are applicable for engineering sector. It will help to better understand the sector and the R&D required for innovative services and providers in Lithuania and abroad.

4. Current version of the database and the core concept of R&D service providers and the engineering industry companies information is implemented here: www.vipkc.lt.

This model will focus on the scientific institution side of the database and their classification inside. To use the database there are two main directions. To search for information using the classificators (where info is classified by Fields of sciences and R&D services) and using the integrated advanced search tool.

In the initial stage, the database will include information about R&D service providers in Lithuania and the services they provide. Companies can find similar companies to collaborate on big projects and research institutions can share knowledge and can collaborate with other institutions for solving science problems and researching new technologies that otherwise would be impossible to do alone.

5. Model can be expanded almost indefinitely to every economic activity there is in NACE. The biggest obstacle to overcome is the creation of custom and intuitive classificators for each and every activity.

This model can also be adapted and integrated to be used with R&D project financing instruments. Using the possible model adaptation that was shown in the paper, companies and institutions can filter all database entries to such detail that only enterprises that are interested into getting financing for a R&D project using a specific financing instrument. Like for example, Horizon 2020, COSME, EUREKA, EUROSTARS.

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ANNEXES

ANNEX 1 Fields of Science Classificator

1.	Natural Sciences	**1.1**	Mathematics	**1.1.1**	Pure mathematics, Applied mathematics
				1.1.2	Statistics and probability
		1.2	Computer and information sciences	**1.2.1**	Computer sciences, information science
				1.2.2	Bioinformatics
		1.3	Physical sciences	**1.3.1**	Atomic, molecular and chemical physics
				1.3.2	Condensed matter physics (including formerly solid state physics, superconductivity)
				1.3.3	Particles and fields physics
				1.3.4	Nuclear physics
				1.3.5	Fluids and plasma physics (including surface physics)
				1.3.6	Optics (including laser optics and quantum optics), Acoustics
				1.3.7	Astronomy
		1.4	Chemical sciences	**1.4.1**	Organic chemistry
				1.4.2	Inorganic and nuclear chemistry
				1.4.3	Physical chemistry, Polymer science, Electrochemistry
				1.4.4	Colloid chemistry
				1.4.5	Analytical chemistry
		1.5	Earth and related environmental sciences	**1.5.1**	Mineralogy
				1.5.3	Geochemistry and geophysics
				1.5.4	Physical geography
				1.5.5	Geology
				1.5.7	Meteorology and atmospheric sciences
				1.5.8	Climatic research
				1.5.9	Oceanography, Hydrology, Water resources
		1.6	Biological sciences	**1.6.1**	Cell biology, Microbiology
				1.6.2	Virology
				1.6.3	Biochemistry and molecular biology
				1.6.4	Biochemical research methods
				1.6.5	Mycology
				1.6.6	Biophysics

				1.6.7	Genetics and heredity
				1.6.9	Developmental biology
				1.6.12	Marine biology, freshwater biology, limnology
				1.6.13	Ecology
				1.6.15	Biology, Evolutionary biology, other biological topics
		1.7	Other natural sciences	**1.7.1**	Other natural sciences
2	Engineering and Technology	**2.1**	Civil engineering	**2.1.1**	Transport engineering
				2.1.2	Architecture engineering
				2.1.3	Construction engineering, Municipal and structural engineering
		2.2	Electrical engineering, electronic engineering, information engineering	**2.2.1**	Electrical and electronic engineering
				2.2.2	Robotics and automatic control
				2.2.3	Automation and control systems
				2.2.4	Communication engineering and systems, telecommunications
				2.2.5	Computer hardware and architecture
		2.3	Mechanical engineering	**2.3.1**	Applied mechanics
				2.3.2	Audio engineering, reliability analysis
				2.3.3	Thermodynamics
				2.3.4	Aerospace engineering
				2.3.5	Nuclear related engineering
		2.4	Chemical engineering	**2.4.1**	Chemical engineering (plants, products)
				2.4.2	Chemical process engineering
		2.5	Materials engineering	**2.5.1**	Materials engineering
				2.5.2	Ceramics
				2.5.3	Coating and films
				2.5.4	Composites (including laminates, reinforced plastics, cements, combined natural and synthetic fiber fabrics; filled composites)
				2.5.5	Paper and wood; textiles; including synthetic dyes, colors, fibers
		2.6	Medical engineering	**2.6.1**	Medical engineering technologies
				2.6.2	Medical laboratory technology
		2.7	Environmental engineering	**2.7.1**	Environmental and geological engineering, geo-technics technologies

				2.7.2	Petroleum engineering, (fuel, oils), Energy and fuels
				2.7.3	Remote sensing
				2.7.4	Mining and mineral processing
				2.7.5	Marine engineering, sea vessels
				2.7.6	Ocean engineering
		2.8	Environmental biotechnology	2.8.1	Waste treatment biotechnology
				2.8.2	Bioremediation, diagnostic biotechnologies in environmental management
				2.8.3	Environmental biotechnology related ethics
		2.9	Industrial Biotechnology	2.9.1	Bio products, biomaterials, bioplastics, biofuels, bio-derived bulk and fine chemicals, bio-derived novel materials
				2.9.2	Bioprocessing technologies, biocatalysts, fermentation
		2.10	Nano-technology	2.10.1	Nano-materials
				2.10.2	Nano-processes
		2.11	Other engineering and technologies	2.11.1	Food and beverages
				2.11.2	Other engineering and technologies
3	Social sciences	3.1	Economics and business	3.1.1	Economics, Econometrics
				3.1.2	Industrial relations
				3.1.3	Business and Management

ANNEX 2 R&D Services classificator

R&D	**1**	Business development	**1.1**	Market analysis
			1.2	Business development strategies
			1.3	Regional development
			1.4	Business process management
	2	Industrial development and production	**2.1**	Idea commercialization
			2.2	Technology transfer
			2.3	Prototype development and design
			2.4	Rapid manufacturing and prototyping
			2.5	Product development
			2.6	Robot technologies
			2.7	Modern manufacturing methods
			2.8	Automation
			2.9	Production and manufacturing process simulation and development
			2.10	Virtual reality technologies
			2.11	Noise, vibration and structural dynamics
			2.12	Design and machining of micro and precision mechanics
			2.13	Filtration techniques
	3	Productivity and management	**3.1**	Competence development
			3.2	LEAN
			3.3	Organizational development
			3.4	Quality and environmental management
			3.5	Business management technologies development
			3.6	Risk and safety management
			3.7	Managing the production environment
	4	Transport and logistic	**4.1**	Vehicles and engines
			4.2	RFID (Radio-frequency identification) technology
			4.3	Logistic
			4.4	ICT in transport
	5	Innovation management	**5.1**	Innovation training
			5.2	Open innovations
			5.3	Service innovations
			5.4	Collaborative networks
	6		**6.1**	User interaction technologies

		Information and communications technology (ICT)	**6.2**	Context adaptive user interaction technologies
			6.3	Media technology
			6.4	Radio systems
			6.5	Software technologies
			6.6	Wireless sensor technologies
			6.8	Information and security
			6.9	Network of control systems
			6.10	Converging networks
			6.11	IT business and competence development
	7	Energy	**7.1**	Flow simulation and thermal calculations
			7.2	Burning stoves, Oil-fired furnace and boilers
			7.3	Heat pumps
			7.4	Refrigeration technology
			7.5	Plumbing systems
			7.6	Product energy consumption
			7.7	Energy use in engines and vehicles
			7.8	Synthetic fuels and bio refining
			7.9	Fuel cells and hydrogen technology
			7.10	Air emissions
			7.11	Ventilation
			7.12	Wind power
			7.13	Smart grid
	8	Industrial measurements	**8.1**	Materials characterization
			8.2	Calibration and metrology
			8.3	Measuring technologies
			8.4	Welds and welding procedure testing
			8.5	Mechanical testing of metals
			8.6	Mechanical and fracture testing
			8.7	Mechanical testing in simulated environments
			8.8	Numerical modeling of industrial processes and combustion
			8.9	Measurements of water and energy flow
			8.10	Water chemistry and electrochemical corrosion research
			8.11	Pipe systems and components
			8.12	Damage and failure analysis

			8.13	Type testing, risk assessment and CE marking
	9	Surface technology	9.1	Micro technology and surface analysis
			9.2	Nano and Micro process technology
			9.3	Nano materials
			9.4	Multifunctional surfaces
			9.5	Surface treatment
			9.7	Antibacterial coatings and hydrogel
			9.8	Thermal spraying and tribology
			9.10	Friction, wear and lubrication
			9.11	Paint and finishes
			9.13	Packing technologies
	10	Materials	10.1	Development of new materials and components
			10.2	Composites and smart materials
			10.3	Clothing and textile
			10.4	Plastic technology
			10.5	Functional polymers
			10.6	Powder development and powder metallurgy
			10.7	Cementitious materials
			10.8	Natural materials
	11	Biotechnology	11.1	Particles and powders
			11.2	Biological testing
			11.3	Medical and pharmaceutical technologies
			11.4	Bio micro systems
			11.5	Nano biotechnology
			11.6	Cell engineering
			11.7	Water treatment technologies
	12	Optical technology	12.1	Optical instrument and device technologies
			12.2	Laser processing of components and products
			12.3	Optical measurements
			12.4	Micro- and Nano photonics

ANNEX 3 Survey questionnaire for problem research

1. How many workers are in Your company?
    A. 1 – 10;
    B. 11 – 30;
    C. 31 – 60;
    D. 60 – 100;
    E. 100 – more.

2. What was the annual turnover of Your company in 2013?
    A. 50k – 250k;
    B. 250k – 500k;
    C. 500k – 1M;
    D. 1M – 3M;
    E. 3M – 5M;
    F. 5M – 10M;
    G. 10M – more.

3. What is the average salary for Your workers with according education levels* (Neto EUR)?

**(check all four rows)*

Middle School diploma	
Bachelor degree	
Master degree	
Doctoral degree	

4. Which University function do you think is the most important to You? Please rate these functions 1 to 5. (*1 – not important, 5 – very important*).
    a. To produce graduates with high-level professional skills and moral integrity to meet the need for human resources;
    b. To generate new knowledge through research and scholarship to strengthen the regional and national economics of self-reliance and international competitiveness;
    c. To provide academic and technical services to state and private enterprises through research training and consultancy activities in order to ensure an efficient transfer of necessary and appropriate technology for social and economic development at regional and national level;

5. Does Your company encounter problems in new product development or new technology implementation?

a. Yes;
b. No.

6. Do You agree that collaboration with Universities can help solve problems when updating current manufacturing technology, designing new high-end products and during other knowledge intensive activities?
   a. Yes;
   b. No;
   c. Maybe.

7. Is it easy to find and access information about the scientific institution capabilities and R&D services, achievements, inventions? Rate it 1 to 5. (*1 – very easy, 5 – very hard*)

   ....

8. Would a service that provides summary of initial information about R&D sector institutions and their services be helpful to establish initial contact with scientific institutions that later could increase to full collaboration effort?
   a. Yes;
   b. No;
   c. Maybe.

9. What do You think are the reasons for not collaborating with Universities and other R&D institutions? Please rate these reasons 1 to 5. (*1 – not important, 5 – very important*).

	1	**2**	**3**	**4**	**5**
The needs of the business do not align with the mission and strategy of the university					
A university does not have the skill set or the facilities to meet the needs of the business					
Hard to find in time an correct partner due to lack of condensed an understandable information about R&D capabilities of scientific institutions					
A university is unable to provide the service required for the price the company is willing to pay					
Failure to agree on the future of the intellectual property that may be generated					
Contrasting views on the management of indemnities and liabilities between prospective partners					
Too much bureaucracy and to successfully start and finish a mutual project in time					

10. Do You believe that collaborating with science institutions can be beneficial to Your Company and can be responsible for more added value to your products and an increase to turnover in the future?
    a. Yes;
    b. No;
    c. Maybe.

11. How much money have your company spent on R&D and innovations in 2012 and what was the increase (or decrease) in company profitability in 2014 when comparing with 2012?

    Expenditure (EUR)..

    Increase (- decrease) in profitability (percent)..................................

12. Do You believe that the partnership between companies and universities should always be measured by artificial metrics to value the relationship?
    a. Yes;
    b. No;
    c. Maybe.

13. Do university teachers have a good understanding about the industry business world?
    a. Yes;
    b. No;
    c. Yes, but not enough.

14. The landscape of collaboration consists of a wide variety of domains where there is real expertise and strength, often of a highly specialist kind. Please read through all of these domains and add a corresponding value to each of them according to importance. (*from 1 to 5*). (*1 – not important, 5 – very important*)

	1	**2**	**3**	**4**	**5**
Future oriented research in advanced technologies					
In house upskilling of employees					
University science park developments					
Support for entrepreneurial research students finding their way in the business world					
Providing progression routes to higher level apprenticeships					
Enhancing the skills of post-doctoral staff for their transition into the business world					
Enabling small companies to recognize the value of employing a first graduate					
Supporting spin out companies from research teams					