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Department of Industrial Engineering and Management

Master's Thesis:

Lean management implementation in Horizontal Technology Transfer projects

by Alena Maslova

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Supervisor: D. Sc. Antero Kutvonen

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ABSTRACT

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The importance of Technology Transfer activities of companies is underpinned by the changes in technological and economic environments. However, there is still a significant gap in defining possible ways for Technology Transfer projects effectiveness improvement.

The Master's Thesis overviews common problems faced by the companies in implementation of Technology Transfer projects and examines Lean management principles as possible way to improve its effectiveness.

Based on the analysis of the relevant scientific literature and results of the survey, conducted among the firms of different types, the approach to Technology Transfer projects implementation with the use of Lean management principles is proposed. The approach serves to solve some of the important problems faced by the managers of Technology Transfer projects. It is envisaged that this approach can help to increase overall Technology Transfer projects' effectiveness.

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"A mind that is stretched by a new experience
can never go back to its old dimensions"
Oliver Wendell Holmes, Jr.

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Lappeenranta, March 2016

Alena Maslova

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ABBREVIATIONS AND DEFINITIONS OF TERMS USED

TT	Technology Transfer
Transferor	A firm transferring its technology to another firm
Transferee	A firm acquiring technology from another firm
OI	Open Innovation
IP	Intellectual Property
R&D	Research and Development
PTD	Potential Technological Distance
JIT	Just-in-Time production system
TPS	Toyota Production System
TPM	Total Productive Maintenance
TQM	Total Quality Management
ANOVA	Analysis of Variance
SVG	Super Value Goods
WIP	Work in progress
FIFO	First in, First out
WMG	Warwick Manufacturing Group
NUMMI	New United Motor Manufacturing
GM	General Motors

1. INTRODUCTION

The importance of the Technology Transfer activities of companies is underpinned by the changes in technological and economic environments. However there is still a significant gap in defining possible ways to increase Technology Transfer projects effectiveness.

At a general level, the objective of the study is to analyze how effectiveness of Technology Transfer projects in different companies can be improved with the use of Lean principles. This study will give instructions on how companies should develop their technology acquisition and commercialization processes in order to be better prepared to meet today’s increasing competition in technology race. The research results should add value to both the transferor and transferee companies and inspire the discussion to further development in the field of Technology Transfer and possible Lean spheres of application.

1.1. Research background and motivation

In the world of ever growing technological opportunities the firm’s competitiveness depends on its capability to observe effectively and catch quickly external opportunities (Iansiti, 1997). Last decades this interrelation has become strained due to some changes happened.

First of all, technology has become more complex. That required companies to cooperate with other companies that had expertise in diverse technical fields. Secondly, the ongoing liberalization of markets enhanced overall competition at the national and international levels. In definite fields of technology new products should appear in the market in a short cycle in order to be able to compete within the sector (Grindley P. C., Teece, 1997).

To keep up with the speed of technological development and global competition, nowadays a company can acquire new technology from others to integrate it into the company’s own settings. Such projects may bring various long-term strategic benefits to both the transferor and transferee companies. For the transferee, Technology Transfer project may help to improve competitive position in the industry by absorption new knowledge. For the transferor, it gives an opportunity to commercialize its unused technologies.

Although technical superiority may not inevitably ensure market leadership and significant revenues, it still remains one of the most important factors providing market competitiveness.

1.2. Defining Innovation models: From Closed to Open

In the times past only large corporations could compete in the market due to possessing such strategic asset as strong internal R&D. If its rivals wanted to beat these companies in technological race they had to spend considerable resources to set up their own labs. And even in the case they could find such financing, these companies still had extremely low chance to succeed. (Chesbrough, 2003)

Anyway, in these latter days large companies have faced significant competition from upstarts without any significant R&D capacities. The shift in the way how companies find new ideas and commercialize them took place. So these new firms started to search new ideas for market outside their company. Consequently, internal R&D has no such strong influence as strategic asset anymore.

Chesbrough (2003) proposed to call the old model “Closed Innovation” (see Figure 1). In such model all the stages of idea generation and commercialization should be held inside the firm. This approach considered to be reliable for a long time as it is based on the evident logical principle: “If you want something done right, you've got to do it yourself”.

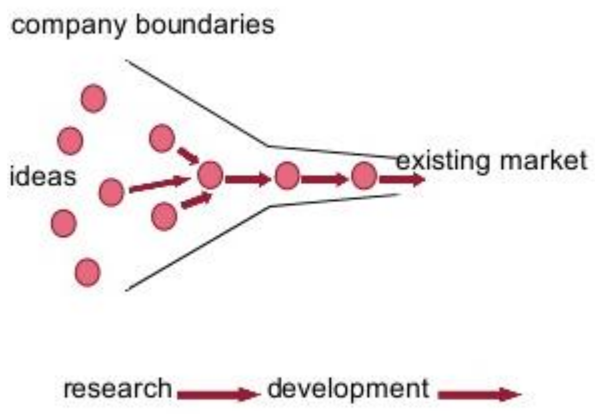

Figure 1. The Closed Innovation model (Chesbrough 2003)

The companies, which were implementing the Closed Innovation model used to invest heavily in R&D activities, they hired people with the best expertise and protected their intellectual property (IP) very aggressively. Thereby, they could capture significant market share. This philosophy of self-reliance was dominating in R&D operations of many industrial leaders for most of the 20th century.

But with time the Closed Innovation paradigm had started to erode. Chesbrough (2003) assumed that one of the most significant reasons of this was the increase in mobility of skilled workers, which made it difficult for companies to control their ideas. Another important issue was related to expansion of venture capital, which allowed small firms to commercialize ideas. Besides the venture capital availability the small companies also got the access to highly-capable outsourcing partners. The last factor mentioned by Chesbrough (2003) was the fact that by that time many companies accumulated significant pool of unrealized technologies which brought on the rise in technology offer in the market.

Due to these factors the new model of Open Innovation (OI) started to grow in popularity. In this model firms got an opportunity to commercialize their unrealized ideas and simultaneously to absorb new ideas from outside (see Figure 2).

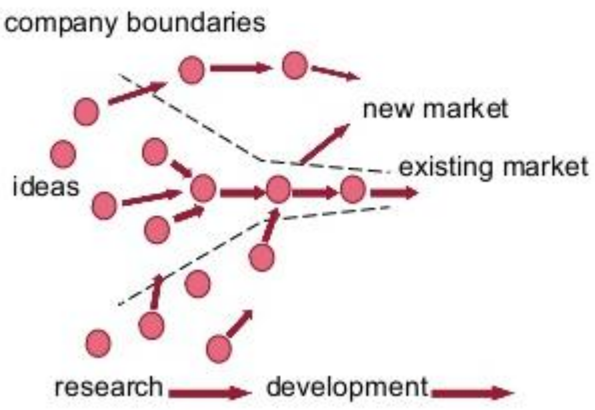

Figure 2. The Open Innovation model (Chesbrough, 2003)

In the Open Innovation model a company should not anymore lock up its IP, but find new ways of getting profit from its' shared possession. In this model there is no need to hire all the best people in industry, as an access to their knowledge and expertise is available outside the firm. Hereupon, building a better business model becomes better alternative than getting to market first (Kline, 2003).

1.3. Technology transfer definition

This study revolves around one precise form of OI - Technology Transfer (TT). Simply stated, Technology Transfer can be performed in two ways: either to acquire the technology from other companies or to commercialize own technologies outside the firm.

Despite the fact that TT is not a new phenomenon, many authors still concur that defining this process is a difficult task due to its complicated nature (Robinson, 1988, Spivery, 1997).

In general, TT can be defined as a flow of human knowledge from one human being to another, whether a transferor or a transferee is an individual, small or large enterprise, a university, a research institution or any other party (Souder, 1990, Ramanathan, 1994).

TT can be carried out over different objects. Typically, such objects are associated with physical assets, for example, equipment, or some form of technical knowledge, which can take form of patent, documentation and others (Bozeman, 2000). Osman-Gani (1999) notices that TT project can be implemented through the exchange of capabilities.

There are various forms through which TT occurs. In this research the commercial Transfer of Technology between the companies is of interest. Such transfer may occur through tangible and intangible property purchase (production lines, factories), where patents would normally be transferred together with tangible assets. Another option is to make transfer through licensing (patents, trade secrets and know-how). The last form through which commercial TT may occur is through the transfer of technology services, acquired from experts (Barton, 2007).

1.4. Lean management definition

The study aims to understand if Lean management can be applied to increase TT projects effectiveness. Though many authors have made attempts to define the concept (e.g. Lewis, 2000; Hines et al., 2004; Shah and Ward, 2007), the definition of Lean management stays rather vague (Bartezzaghi, 1999).

The term Lean was first mentioned by Krafcik (1988). And after that, Womack, Jones, and Roos (1991) used this term to describe the Toyota production system (TPS).

Lean management can be defined as a complex system including a variety of management principles that aim to provide perfect value to the customer reducing the operating costs through the elimination of waste in all forms and enhancing product variety (Shah, Chandrasekaran, & Linderman, 2008, Sanchez and Perez, 2001, Womack and Jones, 1996, Monden, 1983).

Due to Carlson & Ahlstrom (1996), Womack et al. (1996) and Clarke and Fujimoto (1990) Lean management can be characterized by the following characteristics: single piece production flow, just-in-time giving low inventory, small batches, elimination of waste, continuous improvement, zero defect, customer pull rather than organization push, decentralization, integration of functions, simplified information flow and processing, defect prevention, flexible, team-based work organization with multi-skilled workforce, active involvement in root cause problem solving and short time to market.

In this research Lean management will be addressed as a variety of tools and techniques linked together.

1.5. Research gap and research objectives

There are significant gaps in existing literature, firstly, due to a lack of guidelines and principles by which to shape the processes of Technology Transfer and its corresponding organizational structure, and, secondly, due to a limited understanding of Lean management applicability to TT projects. That is why a problem of existing methodological frameworks adaptation to TT projects management arises.

Thus, the thesis aims to understand if Lean management principles are able to solve the problems arising in TT projects implementation, and if so, to propose an approach of Lean management principles application to TT projects implementation.

According to these objectives, two research questions were formulated. Firstly, there is a variety of issues which may deter the companies from implementing TT projects and not all of them can be solved with the use of Lean management. Thus, the first research question, that should be considered, is:

1. ***Do companies face any problems which can be solved by Lean management principles while implementing TT projects?***

Secondly, the most confusing task for managers remains to be a lack of clear guidance to TT projects implementation. Therefore, the second research question is:

2. ***How to apply Lean management principles to TT projects between the companies?***

By answering these research questions, we will provide conclusion on which factors prevent the companies from successful TT projects implementation and how these projects can be realized more successfully by the use of Lean management.

1.6. Structure of the thesis

The thesis contains five chapters and has the structure as presented in Figure 3.

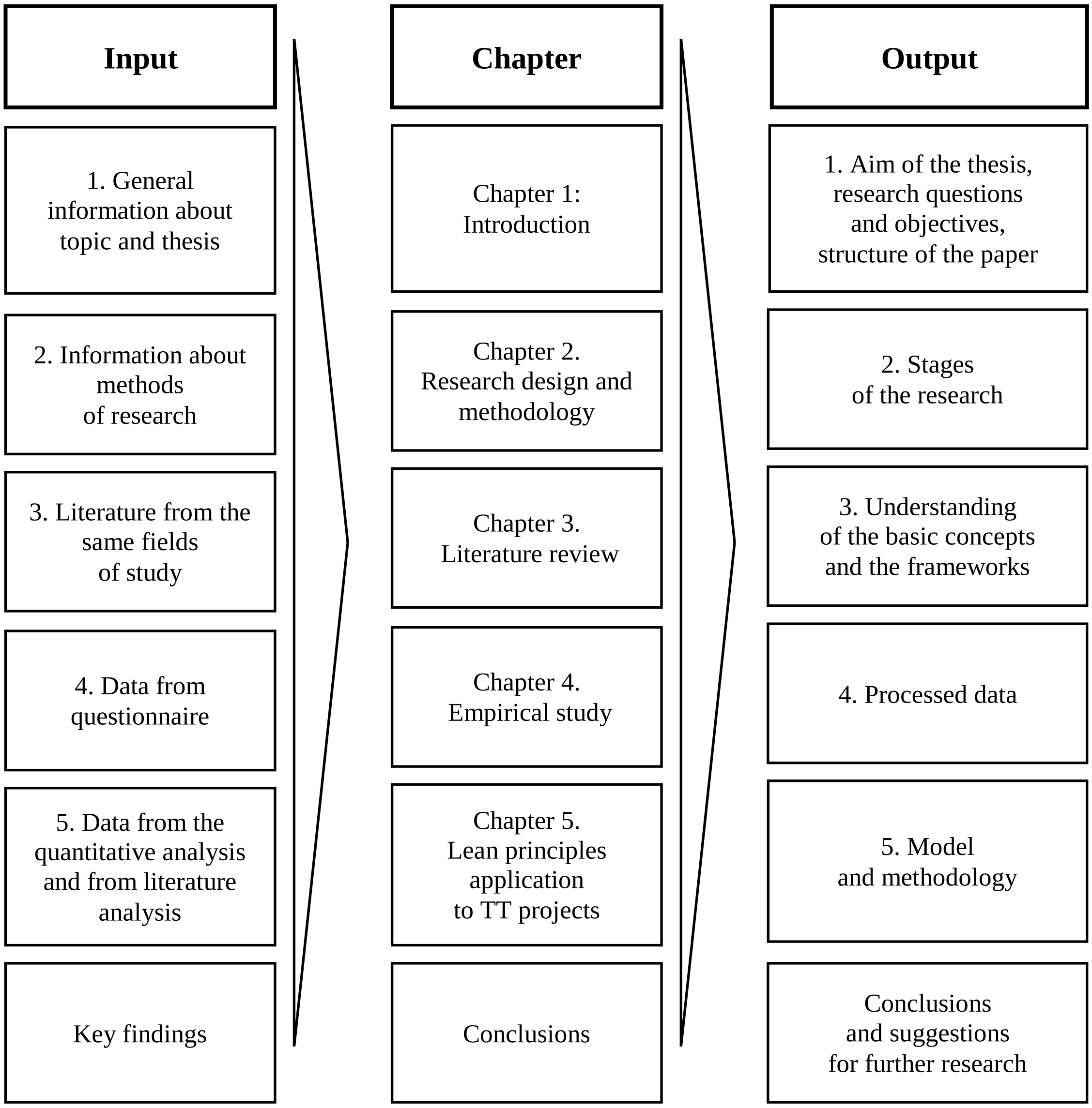

Figure 3. The structure of the thesis

The first chapter is introduction, which provides reasoning for the research, all necessary background information and sets the research questions and objectives. The first section of the paper explores extant theory and suggests that it is necessary to propose a new approach to TT implementation projects. After the introduction, the second section summarizes the research methodology. The third section reviews the existing literature about common benefits of being “opened”, basic Technology Transfer models and the most significant problems arising in the companies while implementing TT projects. It also touches upon the Lean concept, namely, its applicability to TT projects, frameworks, tools, major principles of its implementation and effectiveness evaluation of its appliance in the companies. The forth section presents data collection and analysis. It explores the main TT problems faced by the companies and with recommendations for its solving. Fifth chapter proposes a model of TT project implementation with the use Lean management principles. The final chapter discusses results and implications and gives conclusion.

2. RESEARCH DESIGN AND METHODOLOGY

This research is qualitative with the elements of quantitative analysis conducted with the SPSS software. Literature analysis presents the overview of the main problems in TT projects implementation at each stage and the main techniques associated with Lean management. Quantitative analysis of 42 companies allows examining of these problems in order to evaluate which of them are significant and which are not and also to find out interdependencies between variables analyzed.

2.1. Research design, credibility of research findings and limitations

This study is using Survey as the research design strategy (Saunders et al., 2009). This type of strategy allows quantitative data collection through the questionnaire. Data gathered can be used to define relationships between variables (Saunders et al. 2009).

This study has several limitations. First, the sample consists mostly of Russian companies, but it does not take into account other countries. Though the focus of this study is only internal environment of the companies, it still influenced a lot by the country of the companies' origin. Further researches may consider stated problem in different countries and evaluate location influence on internal environment of the company.

Second, the level of analysis is restricted to the project level, which doesn't take into account long-term technological strategies of the companies. Further researches may complement to this study by analyzing the problem stated on the whole company level.

2.2. Data collection

This study is based on the survey, which was done in 2016 year. Data were collected through the structured interview in the form of the questionnaire, which was sent to top managers in logistics, engineering, system administration, quality control, customer relationships departments, as key respondents.

The objective of this questionnaire is to attempt to understand the nature of Technology Transfer between companies. The questionnaire consists of the questions about the problems, arising during TT projects implementation. It also explores the main types of costs and stoppages arising during the projects.

For the companies, which have any experience in TT projects implementation, it the questionnaire asks, what difficulties they faced and what kinds of wastes appeared during all the steps of the projects. For the companies, not experienced neither in TT, the questionnaire tries to find out main reasons stopping companies from TT projects implementation.

2.3. Sample description

The sample for the quantitative analysis contains 42 companies from following industries: energy, materials, consumer durables and apparel, commercial and professional services, chemicals, hotels and restaurants, household, health care, financials, real estate, software, hardware and equipment.

Most part of responses was gathered from Russia, but still some responses were collected from such countries as Finland and Germany. Sample represents small, medium and large enterprises in approximately equal parts (see Figure 4).

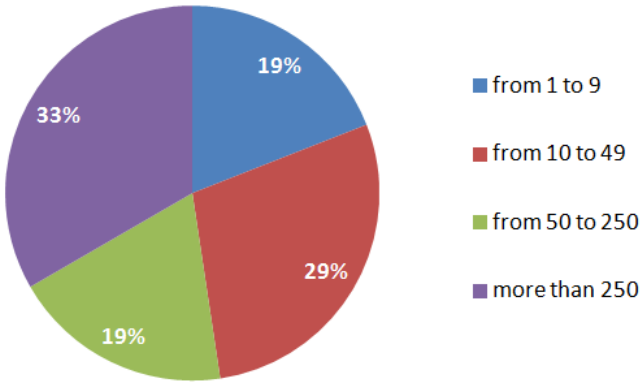

Figure 4. Amount of employees in participating companies

Concerning Technology Transfer activities, the companies have diverse experience. Through the examination of responses it emerged that while 90,4% of the firms once in a while were scanning for new external technologies and 90% of the companies undertook attempts in the search of technologies commercialization opportunities, only 82,2% of them started actual negotiations with potential partners. However, 73,8% of them went through the stage of actual technology acquisition and only 42,9% of the companies commercialized its technologies to partners (see Figure 5).

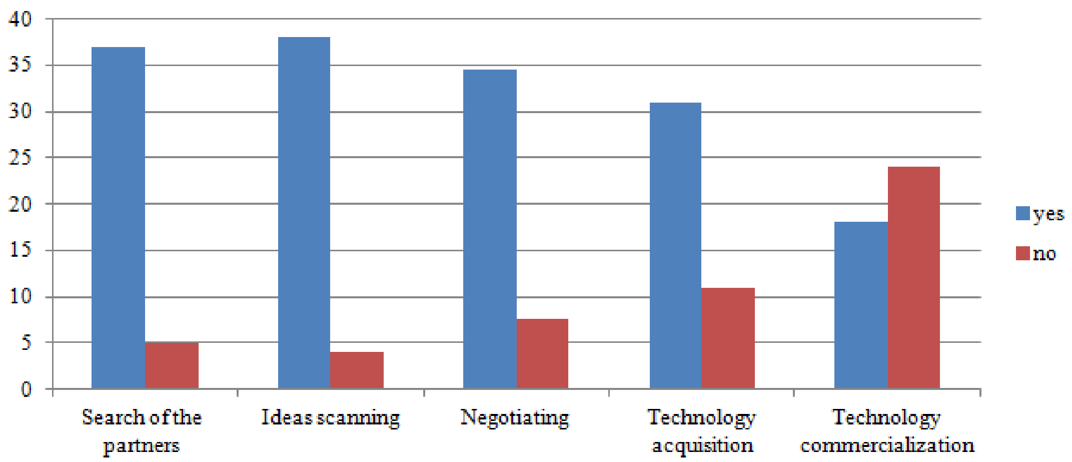

Figure 5. Level of the companies' experience in TT activities implementation

Therefore, the sample consists mostly of the companies which either already had experience in TT projects implementation or at least undertook some attempts in these activities.

2.4. Methods of analysis

Empirical part includes analysis of means, cross tabulation analysis and ANOVA. Analysis of means was implemented in order to evaluate the level of importance of each problem proposed. Cross tabulations aim to find out correlations between such variables as the age of the company and amount of employees and intensity of activities undertaken in the field of TT.

ANOVA analysis aims to find out if there is any statistically significant difference in TT activities intensity between the groups of the companies of different amount of employees and different age.

3. LITERATURE REVIEW

This part represents review of the academic literature related to the topic of Technology Transfer and Lean management. Search for the relevant studies was conducted through the several databases, including EBSCO and Scopus. The search criteria for the literature search were following key words: “Technology Transfer”, “Open Innovation”, “Competitive advantage”, “Technology Transfer models”, “Technology Transfer problems”, “Lean”, “Frameworks”, “TPS”, “Lean toolbox” and the others.

3.1. Technology Transfer projects

This study aims to define what problems companies face in TT projects implementation and what issues stop them from commencing such projects. To understand this, TT core principles and main benefits are reviewed in this section with description of its most wide spread models.

One of the main reasons stopping the companies from TT projects implementation is the fact that they simply can’t understand if strategy of being “Opened” can provide them with any significant benefits which can be derived in the context of long-term competitive advantage.

3.1.1. Competitive advantage of being “Opened”

To understand how Open Innovation influences competitive advantage it is crucial to analyze two its fundamental drivers – cost and differentiation (Reed and Storrud-Barnes, 2012).

Three main types of rents which have importance for analysis of the open strategy are Monopoly rents, Ricardian rents and Innovation rents. Teece (2014) states that monopoly rents can be referred to supernormal profits earned arising from the monopolist restricting demand to raise price without fear of entry by new rivals. These barriers to entry are scale and capital requirements, product differentiation and absolute cost advantage (Bain, 1956).

Lieberman (1987) and Porter (1980) also distinguished such sources of barriers to entry as experience-curve effects, customer switching-costs, access to distribution channels, and other cost advantages.

Ricardian rents originate from owning scarce and valuable resources (Mahoney and Pandian, 1992). Hall (1993) mentions reputation, employee knowhow, culture, networks, and databases as the sources of Ricardian rents.

The third type is Schumpeterian innovation rents. In the paradigm of Open Innovation such rents disappear as being "open" bound to reveal the basic technological knowledge. In this paradigm rivals have not anymore to reverse-engineer technology or to come round patents.

Based on these considerations Reed and Storrud-Barnes (2012) proposed a framework for understanding connection between Open Innovation and competitive advantage of the firm (see Table 1).

Table 1. What open innovation allows and takes away (Reed and Storrud-Barnes, 2012)

		Monopoly rents	Ricardian rents
Cost	**Allows**	Rents from barriers to entry from economies of scale in such areas as operations, and from experience curve effects in operations and knowledge management	Rents from employee know-how in such areas as operations, from organization culture, and from the network relationships with leaders in open innovation community
	Takes away	Rents from barriers to entry from scale benefits in innovation, and access to and the cost of capital	Rents from ability to capitalize on innovation synergies from R&D spillovers and the interaction between internal and external sources of innovation
Differentiation	**Allows**	Rents from product differentiations, distribution channel-control, and customer switching costs	Rents from firm reputation, employee know-how in such areas as operations, and organizational culture
	Takes away	Rents from proprietary product design	Rents from employee know-how and a culture that anticipates customer needs

Karakaya (2002) states that the firm by implementing Open Innovation will possess monopoly rents from experience-curve effects, but the rents from economies of scale and capital requirements will be decreased. As overall level of market competitiveness increases with reduction of costs of innovation and wide access to new sources of capital rents from barriers to entry will be reduced (Kandampully, 2003).

Hall (1993) points out that cost-based Ricardian rents of organizational culture and partnerships will stay after implementing OI model, but the rents from employee knowledge will be reduced. Barney (1986) adds that the possibility of R&D spillovers and the possibility of missed chances of R&D cooperation will increase in this case.

Differentiation Monopoly rents after the company's OI implementation remain unaltered except reduced rents from IP rights possession (Karakaya and Stahl, 1989).

Differentiation-based Ricardian rents from reputation will stay, though the rents from organizational culture and employee knowledge, especially the understanding how to satisfy customer needs, will be reduced (Fuller et al, 2008).

Results of Reed and Storrud-Barnes (2012) study can be better understood through Laursten and Salter (2006) findings that increased breadth and depth of external technology searching lead to cost savings. That is why companies' external technology search and commercialization provides an opportunity to get significant competitive advantage.

3.1.2. Technology Transfer project implementation

The next issue which should be taken into consideration is the way how the company should implement TT projects. J.-P. Escher's (2005) integrative model of technology marketing provides deep insight into TT projects nature.

3.1.2.1. Escher's Integrative model of Technology Transfer

The companies performing its technologies commercialization and implementing external technologies acquisition have significant distinctions in the stages of Technology Transfer implementation. The company's performance in technologies acquisition can be called outside-in flow of technology, in technology commercialization – inside-out technology flow. The process of Technology Transfer as integrated system of two technology flows was proposed by J.-P. Escher (2005) (see Figure 6).

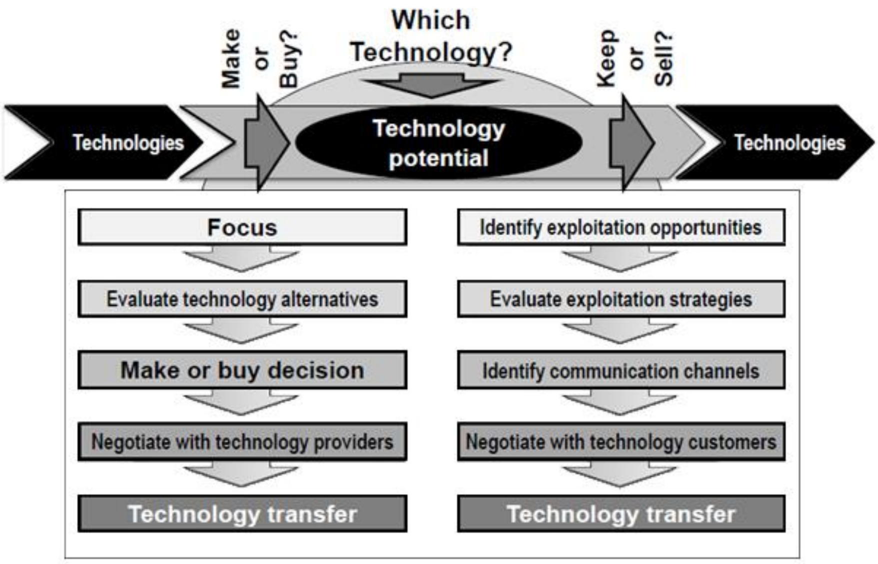

Figure 6. Integrative model of Technology marketing (J.-P. Escher's, 2005)

Outside-in flow starts from formulating requirements to necessary for the company technology. After this all the possible technology options, satisfying all requirements are formulated. On the next stage the comprehensive analysis of all possible financial and strategic benefits of all the options is conducted. These benefits should be compared to the benefits of creating required technology inside the firm. If eventually the company decides that concrete technology acquisition from outside is worthwhile then company can start its arrangements to negotiations and contracting the right technology donor. Logical consummation of this flow is physical technology transfer implementation (Escher, 2005).

On the first stage of inside-out flow the company chooses from its technology portfolio those appropriate for external exploitation. After this the company identifies all possible strategies of these technologies commercialization. Decision “Keep-or-Sell” is taken on the base of many factors such as profitability, access to new strategic opportunities and new networks, learning effect while conducting R&D, setting standards in the industry and others. After the choice of Technology Transfer strategy the company identifies communication channels with future technology recipient. Next stage includes negotiating with chosen potential partners – technology recipients. Last stage is Technology Transfer implementation (Escher, 2005).

When the company simultaneously performs both types of Technology Transfer it can develop the system of constantly renewing up-to-date knowledge inside the firm. However, such approach requires from a company high level of cooperation of many participants, that significantly complicates the monitoring processes for TT projects implementation.

Decision making process of the companies on whether it is worthwhile to acquire technology from outside or participate in external technology commercialization is an extremely important step, at which the company may reject the idea of technology marketing realization. The next section provides a brief overview of what issues should be taken into consideration in making Make-or buy and Keep-or-Sell decisions.

3.1.2.2. Make-or buy and Keep-or-Sell decisions

Decisions “Make-or-buy” and “Keep-or-Sell” are decisions which should be made on the basis of deep comprehensive system analysis of technology, market, technology applications, organizational structure of the company, external environment and other factors. Two sums of possible financial and strategic benefits of traditional technology exploitation and external strategy should be compared in order to make correct decision (Escher, 2005) (see Figure 7).

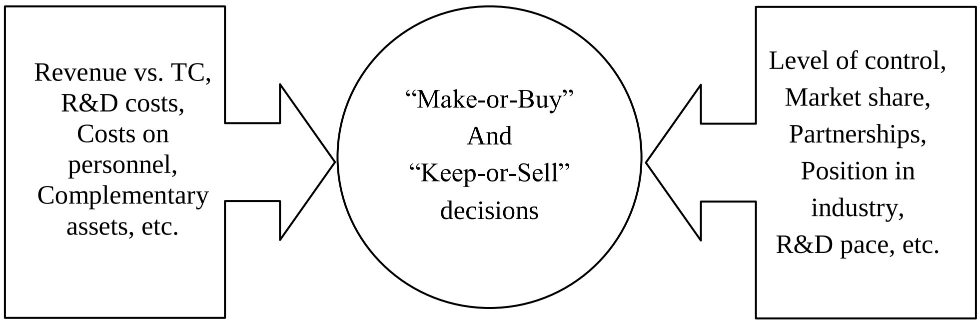

Figure 7. Factors, influencing "Make-or-Buy" and "Keep-or-Sell" decisions

When the company decides on whether it will acquire technology from outside or make it by its own it should analyze many factors. If the company creates the technology by itself it gets an advantage of having the possibility to better control the process, in terms of the duration, geographical coverage and scope, the technology developed through IP protection. It also avoids being dependent on technologies which have been created and owned by others.

On the other hand, investment in research and development can be expensive. There is no guarantee that such investment would bring any fruitful results. In addition, if a company has no expertise in the field of technology under research, it may take a long time to develop such expertise. Sometimes, that is not a viable option because competitors' technical capability and the market may develop much faster than internal research of the company.

Another path, that is, to acquire technology from others, is indeed an option if the required technology is available and accessible in a less risky, more efficient and more economic manner. Possible benefits from the effect of training in the implementation of R & D, access to new opportunities and partner networks should be evaluated.

Profit from the implementation of each of the strategies should be estimated. Detailed calculations of the economic viability of projects should be carried out. Transaction costs analysis is next important part of these calculations. While carrying out the technology transaction outside the organization borders, the company should take into account two types of transaction costs - «ex-ante» and «ex-post». «Ex-ante» include the cost of finding partners, data collection about the partners, evaluation of data and costs of negotiating and contracting the partner. Costs «ex-post» include costs of monitoring recipient’s performance and imposition of sanctions in case of its non-compliance with conditions (Williamson, 1981).

Next important issue which should be taken into account is complementary assets. It is necessary to identify which complementary assets are required for the achievement of the planned production rates and the specified quality level. After this company should determine which part of the assets is already available to the company and what should be purchased additionally.

Another extremely important issue to be checked is the company's ability to carry out effective dissemination of the products. The effectiveness of marketing and logistics policies are analyzed and the resources available for their implementation. The degree of IP protection should be also thoroughly evaluated.

In terms of personnel competencies the financial and time recourses of its purchasing and training to needed competency level should be estimated. Taking the decision “Make-or-Buy” the company should pay special attention to analysis of inventive and absorptive capacities of the firm (Lichtenthaler and Lichtenthaler, 2009).

While making the analysis of external environment of the partner company the resource availability of complementary assets, output, market share, and other factors should be checked. As external environment of the donor company - external factors affecting the company's ability to produce the products of a certain quality level and at defined pace considered.

Decision “Keep-or-Sell” should be taken on some other considerations besides profitability, external and internal environments of parties, transaction costs analysis and IP protection degree. The company can be interested in setting standards in the industry and in this case it will be worth technology selling. Another additional advantage is related to the pace of R&D implementation. When the company performs wide technology commercialization through external participants it gets an opportunity to work on its R&D making new products for the market.

Next, the company should carefully analyze the competitiveness level in all the stages of the value chain. For instance, the company may face strong competition in the market of end product, but while it will not happen in technology commercialization. So company should carefully choose its strategy. While making decision “Keep-or-Seel” company should analyze its innovative and desorptive capacities (Lichtenthaler & Lichtentaler 2009).

It is important to realize that for small and large enterprises the important for the analysis issues will be different.

For large enterprises decision “Keep-or-Sell” is made on the base of comparison two different forces – revenue from licensing and rent-dissipation effect emerging from market share reduction. Often this negative effect can be minimized by restrictions imposition on the recipient’s production distribution by setting territories exclusivity or by the possibility to control the recipient’s profitability (Arora A., Fosfuri A. & Gambardella, 2011). If the transferor and the transferee operate in different markets such problem even may not appear.

In the case of decision making by small and medium sized enterprises the main stress is layed on complementary assets availability.

High-tech small businesses are heavily dependent on opportunities to sell their technology, as they often do not have sufficient resources for the acquisition of complementary assets. Therefore, a decision about the exploitation of external opportunities will be based on a comparison of the cost of acquisition of complementary assets, manufacturing and distribution of products with the cost of the TT.

Decision making process about external opportunities exploitation by small and medium-sized enterprises is more risky in itself. While implementing technology commercialization by itself such firms will likely to face two important problems. Acquired complementary assets usually have a longer life cycle than the technology itself and the company may become tied to the existing assets and will be forced to adjust its further activities for them. Secondly, from the long-term perspective the innovative potential of the firm may be reduced. With the acquisition of complementary assets the size of the company grows, so speed of information flow may reduce. (Fosfuri and Gambardella, 1999).

In the case the company decides to implement external technology acquisition or commercialization it should make a choice of TT mechanism which will be used. For the sake of combining a comprehensive approach to TT project implementation next sections review existing TT models.

3.1.2.3. Transferor and Transferee chains' connection

According to Ramanathan (2000), TT can be regarded as the system of two interconnected processes – generation and assimilation of technology (Ramanathan, 2001). This is shown schematically in Figure 8.

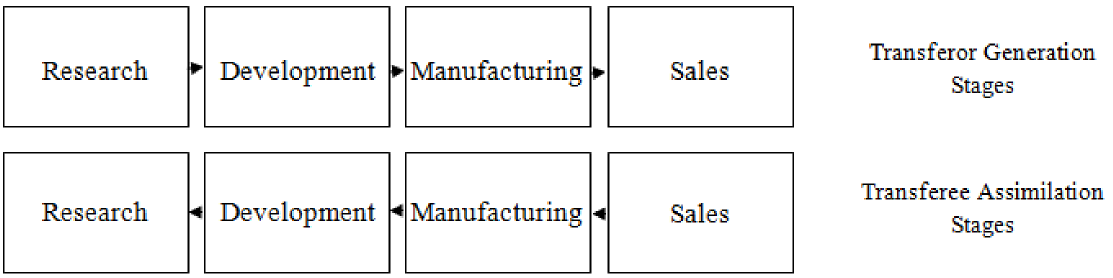

Figure 8. The technology development chains of the transferor and transferee (Ramanathan, 2000)

Ramanathan proposed to divide TT into four basic categories: sales intensive, when the final product is simply being sold by the recipient; manufacturing intensive, when transferee acts like a manufacturing partner (subcontracting arrangements, production licensing, etc.); development intensive (for example, original design manufacturing) and research intensive (joint R&D and production, university – industry licensing, etc.) (Ramanathan, 2000).

The choice of the technology transfer mechanism will depend on how the technology development chains of the transferor and transferee are linked. The type of the chains' connection in turn will depend on the corporate strategies of the transferor and transferee and the technological capability of the transferee.

There were conducted a significant amount of studies about technology transfer implementation. All of them for the purpose of discussion can be divided into qualitative models and quantitative (Ramanathan, 2000).

3.1.2.4. Models of Technology Transfer

In order to get a holistic picture of TT project nature some of the main qualitative and quantitative models are reviewed in the following section.

3.1.2.4.1. Qualitative Models of Technology Transfer

Qualitative models aim to define the activities of TT projects and the factors influencing TT projects success. (Jagoda, 2007)

Bar-Zakay (1971) presented a qualitative model of TT, consisting of four stages which are presented in the Figure 9.

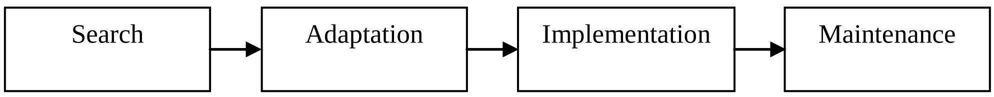

Figure 9. Bar-Zakay Model of TT (Bar-Zakay,1971)

His model was further improved in 1996 year to the UNIDO model, which proposed to distinguish following project steps: technology search, evaluation, negotiations with the partner, contracting, TT implementation and technology adaptation. It was proven that following these steps a company will improve overall project effectiveness (UNIDO Manual on Technology Transfer Negotiation, 1996).

Another seven stages qualitative model was presented by Behrman and Wallender (1976). The stages presented are the following: decision making about the recipient of technology, development of the product design of technology to be transferred, defining the stages and of the production process, physical technology transfer and equipment adjustment, production commencement with further adaptation of the process to transferee environment, the use of local knowledge to improve the technology and providing further assistance in technology assimilation.

Chantramonklasri (1990) proposed a five phase model which is presented in Figure 10.

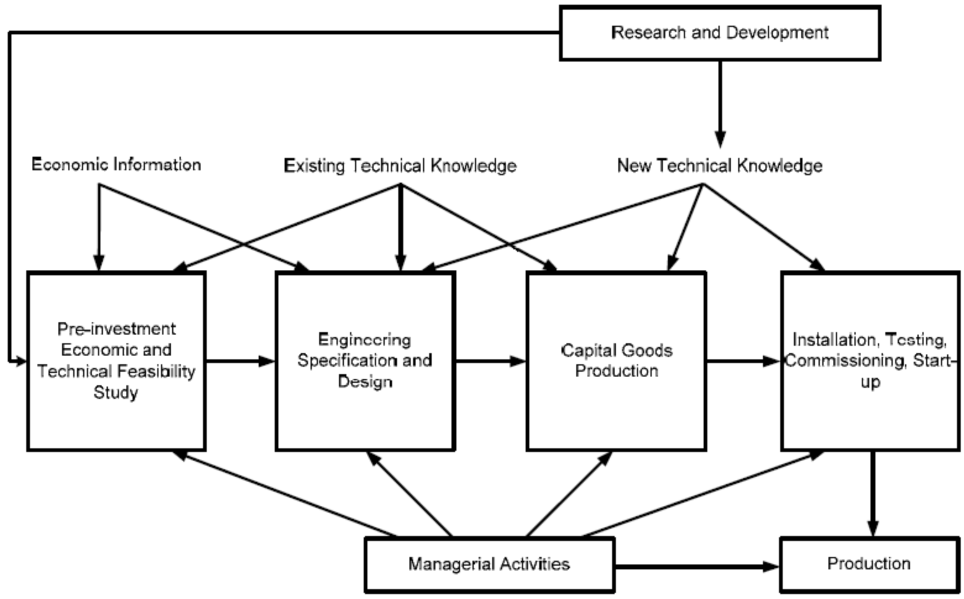

Figure 10. The Five-phase model of international technology transfer (Chantramonklasri 1990)

This model begins with detailed analysis of feasibility and required investments and then it comes to specifications of the technology to be transferred. Complementary equipment and machinery needed are produced, installed and adjusted. After this, the production is commenced and intensified.

The last qualitative models to be observed are the model proposed by Durrani et al. (1998) and the Bozeman's model (2000). The first model includes five stages: market requirements analysis, identification and classification of possible solutions, identification of potential partner and decision making process (Durrani et al., 1998). The second model observes the main constitutes of TT project, which are the transfer agent, the transfer mechanism, the transfer object, the transfer recipient and the demand environment (Bozeman, 2000).

3.1.2.4.2. A brief overview of Quantitative Models of Technology Transfer

Quantitative models of TT projects are reviewed extremely sparsely in the literature. For the sake of briefness the mathematics is excluded from this section as only theoretical implications present the main interest for the study.

The first quantitative model of TT project was presented by Sharif and Haq (1980). They introduced the concept of Potential Technological Distance (PTD) between TT parties. The main idea of this model is that transferor and transferee should have not too great and not too small PTD between them in order to implement TT project effectively. The main implication which can be made from the model of Sharif and Haq (1980) is that transferor and transferee can estimate quantitatively if the PTD with potential partner is far from "optimal" one.

The second important model was presented by Raz et al. (1983). This model is concentrated on technological "catch-up" concept. It presumes that the transferor of technology can help the transferee to develop its technological level. In this case the transferee is called "Technology follower". The main implication which can be made from this model is that there are three main phases of technology transferee growth. They are first slow phase with significant capability gab, faster learning phase and technological catch-up phase when capability gab is reduced or eliminated at all. Important issue here is to define from the beginning that technology follower potentially can gain planned level of technological development.

The last quantitative model which is reviewed is TT econometric model proposed by Klein and Lim (1997). This model evaluates technology gap between the industries in which the parties operate in order to define how the companies should build their partnership. Namely, which measures should be undertaken to assimilate, improve and localize the technology by the superior transferor. The major implications from this model are the following: firstly, it confirms the concept of Raz et al. (1983) that TT project can play a critical role in technological development of technology follower, secondly, the model underline the importance of post-implementation activities which contribute to further development of both the transferor and transferee.

An examination of qualitative and quantitative models of TT projects implementation shows valuable lessons. First of all, a process approach should be implemented to ensure effectiveness of TT project. Prior to TT commencement the need for TT should be defined and detailed feasibility analysis should be carried out. PTD and ability of the transferee to catch-up technology leader should be evaluated. The comprehensive examination of entire process from requirements identification to further improvements and control should be held in order to avoid possible TT project failure.

3.1.2.5. TT project life cycle model

Standard process of technology transfer can be divided into some universal stages which are planning, analysis of gathered data, negotiating, technology transfer realization and post transfer communication and control (Lichtentaler 2004 35). Such approach is convenient due to its universality.

Taking into account the main implications of reviewed models the six stages model was proposed (see Figure 11).

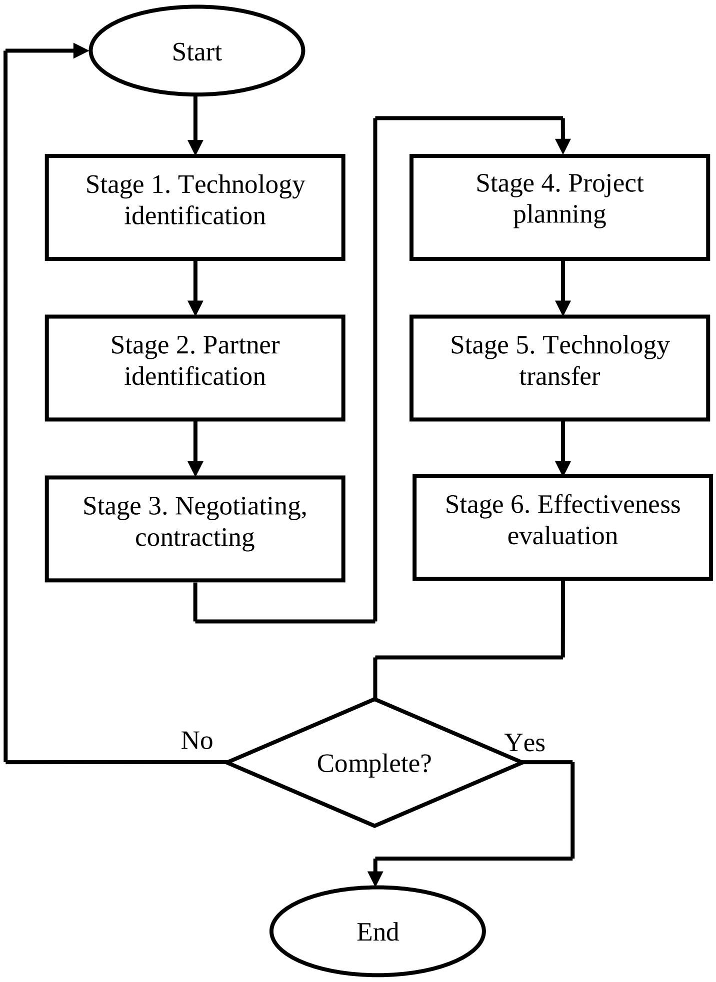

Figure 11. Technology Transfer six stages model

At the first stage the transferee identifies requirements to technology it would like to acquire, makes a list of technologies satisfying these requirements and evaluates each technology. The transferor at this stage identifies and evaluates its own technologies which have potential to be commercialized. At the second stage the parties identify potential partners able either to propose required technology or acquire it. Partners go through negotiations, make a contract and commence the project planning stage. At this stage the TT mechanism is chosen by both parties. It will depend on the companies external settings, its technological capabilities, the level of intellectual property protection needed and other factors. At the fourth stage the actual transfer of technology take place, which includes further improvements and assimilation of technology. At the last stage the companies evaluate effectiveness of the project realized.

Such approach implies that both parties are involved in the process of TT right since the moment of contract award. A technology transfer project does not end with commencement of production. The TT project can't be considered successful unless explicit measures are in place to ensure assimilation of the transferred technology.

3.1.3. Technology Transfer project effectiveness evaluation

TT project can be considered successful if the transferee of technology can effectively exploit transferred technology and, ultimately, to assimilate it (Ramanathan, 1994). However, the transferee and the transferor will have different indicators of successful project implementation.

The overall evaluation of the project successfulness due to the complicated nature depends on many factors. For the transferee the project will be considered successful if it can successfully assimilate the technology acquired, which will depend on its absorption capability (Cohen and Levinthal, 1990). Successful assimilation will also depend on the level of control and assistance from the transferor. The ultimate consequences of the project can be analyzed from the point of market view, financial, technological, organizational and other possible strategic outcomes.

For the transferor evaluation of TT project effectiveness is based mostly on the analysis of financial benefits and not monetary outcomes such as access to new networks, setting technological standards in the industry, control over technology flows and access to new markets (Lichtenthaler, 2007).

Classical metrics of TT project implementation reviews the results of technology assimilation or commercialization. It consists of such criteria as the number of new products produced for the period, the proportion of new products sales to overall sales of the company for the period, the proportion of financial resources spent on TT projects to overall R&D processes of the company.

3.1.4. Technology Transfer problems commonly faced by firms

The main reasons stopping the companies from TT project realization are absence of clearly defined mechanism for project effectiveness evaluation, market share loss, dependency on the partner, detrimental effect on position in industry, R&D spillovers, loss of the customer loyalty, detrimental effect on the core business (Ramanthan, 2000).

Based on the work of Jagoda (2007) and Ramanathan (2007), problems faced by firms in planning and managing technology transfer may be classified into three categories namely, technology transfer process issues, corporate capability issues, and operating environment issues. The problems arising at each step of TT project are summarized in the Table 2.

Among the problems related to corporate capability issues the main important are the following: workforce is not experienced and competent enough, the trainings held are insufficient or ineffective, not-invented-here syndrome, employees are not satisfied, existence of language and cultural barriers.

Among the problems arising due ineffective management following are considered to be the most significant: lack of experienced and committed top managers, absence of clear defined procedures and instructions, inadequate staff allocation for a project, ineffective organizational structure.

Table 2. Technology Transfer problems commonly arising during the project implementation

Stage	Problems
Technology Identification	– locked in complementary assets; – high complexity of technology; – high complexity of assimilation; – necessity of significant adaptation to local conditions; – questionable patent clearance; – obsolescence of technology for the time of TT; – corruption in the choice of technology.

Partner identification	– corruption in partner's choice; – unreliable data gathered about the partner; – small quantity of partners available; – not effective mechanism of partner search; – too complicated communication with possible partner.
Negotiations and contracting	– differences in negotiation approaches and strategies; – differences in working methods; – differences in culture; – goal incompatibility during negotiations; – inability to come up with agreement about the price, marketing and product strategy; – lack of trust; – not effective communication channels.
Project Planning	– not effective communication between partners; – low partner involvement in planning; – unwillingness of the partner to provide all data required; – inaccurate estimation of firm's own capabilities.
Effectiveness evaluation	– high costs and low quality of local suppliers of products and services; – inadequate monitoring and control; – inability to hold scheduled trainings; – failure to gain planned quality score; – inability to meet planned production level; – inability to meet deadlines.

Despite the fact that problems of operating environment and National Innovation System issues remain extremely important they are not the central issue in this study.

3.2. Lean management

Nowadays Lean management principles are no longer fashionable but its main principles have become the paradigm for many organizations (Karlsson and Ahlstrom, 1996) which are adopting it in order to keep their competitive advantage. It came into such widespread acceptance mostly because of the counter-intuitive nature of Lean (Pettersen, 2009).

The central issue of Lean is the customer, which has requirements to the value produced by the company. The customer satisfaction is usually gained by providing the right good or service at high quality, at the right time, place and reasonable price.

Every process in the company consists of a sequence of steps. To provide the customer with perfect value these steps should be taken in the correct order and at the proper time. The main objective of the company is to eliminate all possible wastes arising during the processes of value creation. The Lean concept implies that in order to do so all the steps should add value to the product or service, they should flow quickly from one to another at the pull to the customer (Womack et al. 1996).

In order to understand if Lean is worth to be applied to TT projects, in the next section the main constitutes of its competitive advantage are analyzed.

3.2.1. Lean competitive advantage

Lewis (2000) argues that the implementation of Lean management principles can create strategic resources to consolidate sustainable competitive advantage. The Lewis's study (2000) presents that becoming Lean does not automatically result in improved financial performance. In order to do so the company should develop its ability to use generated savings from wastes reduction.

Competitive advantage emerges when the company can be a successful player in its market, for example, making end products at lower cost or offering more differentiated products. Nanda (1996) explain competitive advantage of the firm using the resource-based theory. He states that competitive advantage arises due to unique internal resources possessed by the company. But for Lean implementation they contribute to the firm's competitive advantage equally important as external market factors do, as they can create barriers to imitation. So in order to get sustainable competitive advantage the firm should implement Lean thinking to both external and internal contexts.

An important implication which can be extracted from the Nanda's study (1996) is that Lean is implemented most effectively in the stable and advantageous situation in country, which is, unfortunately, far from reality, as the majority of modern markets are changing very rapidly. It means that Lean implementation in such environment can create usually only short-term performance advantage which in its turn will contribute to long-term viability (Lewis, 2000). And, ultimately, such contribution will provide the company with sustainable cash flow and market position (Karlsson and Åhlström, 1996).

For understanding Lean competitive advantage in internal context it is reasonable to analyze two different types of learning in organizations, the development of increasingly efficient routines and increased responsiveness to novel situations (Sitkin, 1991). The first type of learning directly arises from Lean's "strive for perfection", while the second goes across its basic principles. It means that Lean adopting firm will more likely will be involved in incremental changes then in its general innovative activity (Lewis, 2000).

TT projects are not related to the basic R&D so the development of increasingly efficient routines suits it perfectly. For instance, as incremental innovations can be implemented in the field of prototyping of new products in order to increase the speed of this process.

Another important issue which should be taken carefully as over time, Lean production may generate system complexity. To avoid this in the company clear methodology and procedures should be used.

Though the term "Lean" has been intensively analyzed in the literature, it is still applied very vaguely and used to describe many things: goals, general methods, specific tools, and the basic foundation. All of the goals, methods, techniques, and foundation elements should be utilized in combination as they can't work without each other (Pavnaskar et al., 2003, p.3077).

Next section reviews Lean applicability.

3.2.2. Lean applicability

Toyota was the first company implementing Lean principles. It demonstrated high performance with its production system established in all multinational manufacturing sites despite mistaken criticism that its success was attributed to the cultural roots, but not lean practices (Wafa & Yasin, 1998).

Womack and Jones (2003) argue that Lean principles can be applied in any country and any industry. It also has covers all aspects of the manufacturing functions from product development, procurement and manufacturing over to distribution (Womack, et al., 1990).

Nevertheless, as usually Lean implemented in high-volume or mass producers, there are little published works (Jina, et. al. 1995) exploring whether Lean management principles are applicable in other industrial sectors characterized by highly differentiated, low-volume production of low repeatability or “super value goods” (SVG) (Gibbons and Nelson, 1978).

Researchers at Warwick Manufacturing Group (WMG) made an investigation to compare Lean practices adopted in SVG companies with high-volume or mass producers. They found out that over 90% of the drivers impacting on a typical lean automotive industry remain applicable to SVG sector (Moore and Gibbons, 1978).

Mike Rother (1998) states that the situations when the end product type varies too much are often considered to be not suitable for continuous flow implementation. But as he also points out, in many processes, even administrative, various benefits of continuous flow implementation can be achieved.

The next important issue about Lean applicability is that each firm should follow its own unique Lean production development way. Each firm has its specific starting settings and specific processes implemented in specific sequence. The scope and content of Lean should be defined before Lean implementation (Crute et al., 2003). The organization should choose appropriate concept to suit the organization’s needs. Lewis (2000) argues that through such process of adaptation to local conditions the firm will be able to successfully implement Lean principles.

Incorrect application of Lean concept may lead to the wasteful spending of the company's internal resources and also it may result in employees' collapse in confidence in Lean (Marvel & Standridge, 2009).

The major difficulties of Lean implementation are usually referred to cultural, managerial, technical and implementation barriers (Flinchbaugh, 1998).

Therefore the comprehensive project-based implementation framework for Lean implementation for Technology Transfer projects should be composed. The next section reviews existing Lean implementation frameworks.

3.2.3. Lean implementation frameworks

Although the benefits of Lean principles implementation are extremely extensive, existing frameworks still look incomprehensible for the companies.

Lean implementation frameworks reviewed in the literature vary significantly. For example, Smeds (1994) proposed a generic framework for Lean management changes based on the principles of innovation management. As an important method of this management framework Smeds applies social simulation games. Jina, Bhattacharya, and Walton (1997) suggested a descriptive diagram for Lean principles applying in the companies with high product variety and low volume. The diagram observes logistics, product design and development where manufacturing is built along Lean principles and supplier relationships are highly integrative. Womack and Jones (2003) described time frame for Lean leap, consisting of four stages from preparation activities to complete transformation of the company. Anand and Kodali (2010) developed a conceptual framework for Lean management implementation divided into several levels, with associated procedures and tools at each of them. Karlsson and Åhlström (1996) presented operational model for the changes required to apply Lean management. Sánchez and Pérez (2001) developed an assessment checklist to evaluate the changes in the company after applying Lean principles. Anvari and Zulkifli (2011) suggested a model for a Lean roadmap to account for the dynamic conditions of a high variability environment. Nightingale and Mize (2002), Feld (2001), Marvel and Standridge (2009) and some others addressed Lean implementation in a form of a roadmap.

Mostafa et al. (2013) distinguished five possible initiatives for Lean implementation. They are roadmaps, conceptual and implementation frameworks, descriptive and assessment checklist initiatives. He proposed an evaluation methodology for Lean implementation initiatives based on analysis of nine success factors, which are expert team building, situational analysis, Lean communication planning, training process, Lean tools, Value Stream Mapping (VSM), Lessons Learned Review, Lean Assessment and Lean Monitoring and Controlling.

According to this study the most successful Lean initiatives turned out to be those introduced as roadmaps and frameworks. Following this logic Mostafa et al. (2013) proposed a project-based conceptual framework with four implementation phases and 15 steps. His simplified and comprehensive implementation framework serves the base for the model proposed to answer the research question of the thesis.

3.2.4. Corporate culture and the fundamental beliefs of Toyota

The Toyota Production System (TPS) is the most famous example of Lean processes in action. This section focuses on the issue extremely important for Toyota's success, its corporate culture and main values.

Husar (1991) in his study about TPS states that the company introducing Lean principles has a responsibility to society and its employees. It should enrich society by contribution through its products and services with high quality, reasonable price, quick delivery or through strong service system. Contribution to the company's employees can be expressed in job security or education opportunities. In whole such company should contribute to national economic system to the best of its ability through creating working places, taxes paid to government and through providing partnership opportunities to other companies in the market. Its relationships with suppliers should be built on cooperation and competition, allowing suppliers to compete producing goods of the higher quality and lower price and simultaneously supporting the growth and stability of companies, for example, through technological assistance.

The first main value of Toyota which was already discussed in the previous sections is customer first. The second value is to create competition and cooperation within the industry. The third value implies respect for the value of people.

The fourth value, mutual trust, means that management and the employees have confidence in one another. Management and their employees have different jobs and different responsibilities in the company. Mutual trust comes from the belief that everyone is working for the same purpose: prosperity of the company, which means better and more secure employment for all.

The fifth value, challenge and courage, states that the company's team members should constantly try to find better ways to do their work. Continuous improvement requires courage. So the team members should be able to propose their ideas without fear of making mistakes. Even if the failure occurs it is possibility to learn from it.

The sixth value is applied creativity or Kaizen, which will be discussed in the next section.

The seventh value of TPS is cost consciousness and continuous cost reduction activities. This value is critical to the company. Toyota does not make a profit by adding to the cost of its cars for the customer. To make a profit, the company reduces the costs for producing its cars.

Clear definition of the values doesn't mean anything without the company's ability to apply these values to all the policies and systems of the company. So objective of the company is to put these values into practice. First of all this is achieved by explaining the values to employees in order they could put them into practice in any situation they face. The principles on how to implement the values are clearly defined by the company.

3.2.5. Lean Toolbox

Toyota puts its values into practice through simultaneous use of "Lean toolbox" and "Lean thinking". To implement Lean managers should take into account both internal focus (Liker, 2004; Ohno, 1988), for instance, cost reduction, and external focus on improving customer satisfaction (Womack et al., 1990).

Karlsson and Alsthrom (1996) describe 18 different elements of Lean management (see Table 3).

Table 3. Lean Toolbox (Karlsson and Alsthrom 1996)

Group, common term	Specific characteristics
Just-in-Time practices	Production leveling (Hejunka) Pull system (Kanban) Takted production Process synchronization
Resource reduction	Small lot production Waste elimination Setup time reduction Lead time reduction Inventory reduction
Human relations management	Team organization Cross training Employee involvement
Improvement strategies	Improvement circles Continuous improvement (Kaizen) Root cause analysis (5 Why)
Defect control	Autonomation (Jidoka) Failure prevention (Poka yoke) Inspection Line stop (Andon)
Supply chain management	Value Stream Mapping Supplier involvement
Standartization	Housekeeping (5S) Standardized work Visual control and management
Bundled techniques	Statistical Quality Control (SQC) Preventive maintenance (TPM)

The first group of Lean characteristics is Just-in-Time practices.

3.2.5.1. Just-in-Time practices

The processes in TPS are organized as continuous flow. It means that only one piece at a time moves from one process to another without inventory between the processes (Liker, 2004). All processes are linked to a pull production, in which downstream activities signal their needs to upstream activities. Pull production strives to eliminate overproduction and is one of the three major components of a complete Just-In-Time (JIT) production system. In JIT production system an actual order is placed, the right item is produced at right time, in right quality (Dennis, 2007).

Heijunka is an important element of JIT production. Due to Heijunka the workload and production is leveled over defined period in order to achieve constant flow of mixed parts and to minimize the peaks and valleys in the workload. Hejunka helps to avoid batching and results in minimum inventories, capital costs, manpower, and production lead time (Furmans, 2005).

Ohno (1978) developed a new way to coordinate the flow of parts within the supply system on a day-to-day basis, called Kanban. In Kanban system parts would only be produced at each previous step to supply the immediate demand of the next step (Monden, 1994). Kanban cards are the best-known and most common example of these signals.

Another important characteristic of JIT system is Takt Time, which is available production time divided by customer demand or the time available to produce one unit of output (Henderson et al. 1999).

3.2.5.2. Resource reduction

One of the main Lean objectives is to identify and eliminate all possible wastes in the process, where waste is everything that does not add any value to the product or service (Womack and Jones, 1996).

Waste is considered to be something for what the customer will not pay. Every company has obvious and hidden wastes. And usually the hidden ones are much higher than obvious. Wastes can take different forms such as costs, materials, equipment, worker hours, documents, movements and others. The seven major types of wastes are presented in the Figure 12.

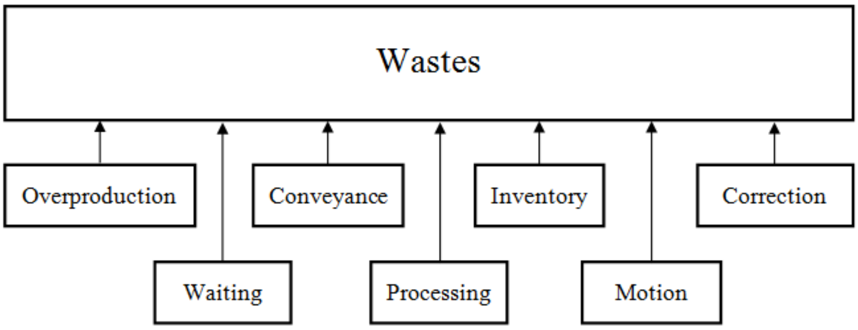

Figure 12. Seven types of Lean wastes

First type of wastes, overproduction, refers to anything produced ahead of what is really needed on the next step of the process. The second type, waiting, refers to time wastes emerging from equipment fails, stoppages in required parts delivery, idlesses of operators and others. Set Up time or change over from running one product to another serves the measure of existing waiting wastes in JIT production (Kilpatrick, 2003). Third type is about unnecessary moving of any parts. It can appear when, for example, process steps are separated significantly in the space. Fourth type wastes appear from extra stages of processing. Inventory wastes refer to presence of extra stocks which impede even flow of entities. Another type, motion wastes, arises when operators have to make unnecessary movements to get parts, documents. The last type of wastes is all types of correction needed (Bicheno, 2000).

Domingo (2012) states that the steps of effective wastes elimination can be following: to identify and understand the wastes, account the wastes, measure them and reduce or eliminate if it is possible.

3.2.5.3. Human relations management

Toyota understands that its employees create value for the customer so the company provides them with an opportunity to contribute their ideas, as well as their labor. The workforce should be used as competitive advantage. The main ideas about Human element in NUMMI are presented in the Figure 13.

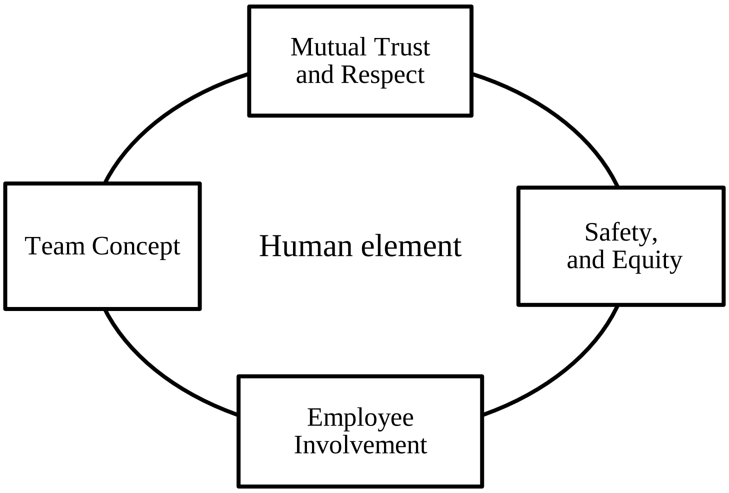

Figure 13. Four components of the Human element of NUMMI's success in Lean implementation

Trust and respect plays an important role in NUMMI's Lean implementation. The employees should feel free proposing new ideas about how to reduce wastes and improve the processes without any fear of job eliminations. Initially mutual trust to employees was shown in Toyota by giving them an opportunity to use Andon system to stop the line when any problem arises.

Laurent (1990) in his overview of NUMMI, joint venture of GM and Toyota, points that the use of project teams is recognized to be one of the most important factors of Lean success implementation. The project teams should be comprised mainly of the people, who come from associated areas and stay in the project for one-three year period. There should not be any barriers between departments, so everyone could easily cooperate with others. Though the subordinates are developed very strictly, the team leaders are selected rather than elected, and they work very closely with the members on their team. Group leaders provide another layer of support for the team members, working side-by-side with the team members and team leaders. Much attention paid to group activities outside the plant in hopes that the team will develop further.

High level of employee involvement can be achieved by reward and recognition programs. Employees are encouraged to *kaizen* their workplace and turn their ideas in for Suggestion Awards. Another recognition program, the Performance Improvement Plan Sharing program (PIPS), provides financial incentives for achieving certain goals and objectives (Bodek, 2010). There are also not financial ways to get team members involved. For example, Problem Solving Circles, for the victory in which employees are awarded free trips.

Equality of treatment can be demonstrated through elimination of distinctions in the workplace, for example, by use of "uniforms," common parking/cafeteria, few offices. The managers, engineers, and other support personnel work in a very accessible open-office environment.

Another success factor can be referred to the training processes. In Toyota and NUMMI for the role of trainers team members are chosen from the plant floor. Trainings should be conducted as much as possible direct tie-in to work environment.

3.2.5.4. Improvement strategies

In Kaizen activities employees contribute to the company’s development through suggestions aiming eliminating of all types of wastes (Imai, 1986). There are two levels of kaizen. First level is system or flow kaizen focusing on the overall value stream. The second level is kaizen focusing on individual processes.

By the use of data collected from quality stations and Andon the condition of entity is observed and recorded. After that it is analyzed through the use of “5 Why’s” the root cause methodology, then countermeasures are developed and the methods for its implementation. In the end the results are evaluated and the process is standardized.

The employees should have the ability to think proactively to devise solutions before problems become serious.

3.2.5.5. Defect control

Jidoka is a process through people and machine detecting abnormal conditions, preventing defective parts of passing to the next process and determining and eliminating the root cause. Jidoka provides machines and operators an ability to detect when an abnormal condition has occurred and immediately stop work. This enables operations to build in quality at each process and to separate men and machines for more efficient work (Dennis, 2007, Haak, 2006).

A Jidoka feedback mechanism includes Andon system and quality feedback information collection system. Detected information about the defects is reported to special production authorities. The Andon system serves as a tool with visual and audio signals indicating the status of the entity's condition (Kasul and Motwani, 1997).

Standardized work is also mandated through the usage of Pokayoke, which is a low cost, error proofing device with high reliability is designed for specific workplace conditions (Shingo, 1989).

Toyota strategically deploys different error-proofing methods that play a significant role as product quality enablers within their production system. This is a very practical and pragmatic look at the principles and strategies which allow truly effective error-proofing (Arnesen, 1997). This not only includes specific technologies applied on the floor, but also the support systems and practices that involve the team members. Together they make quality happen. Specifically mentioned are: support the operator, simplicity, redundant layers, and a shift in thinking (see Figure 14).

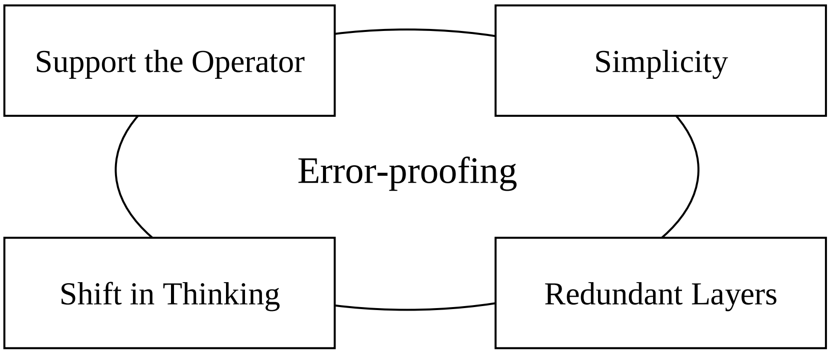

Figure 14. Key Error-proofing principles of TPS

It is important to approach Lean error-proofing from the paradigm of supporting the operator, with no net increase in his/her burden. Most always, each individual error-proofing technique can be very simple and low cost, avoiding operator complexity and downstream maintenance costs. Layering multiple, simple and low cost error-proofing techniques results in extremely robust overall effectiveness. In conclusion, a mindset committed to finding the most effective overall system approach, even if departing from traditional paradigms, will generate an ever increasing application of very effective lean error-proofing.

3.2.5.6. Supply chain management

After setting continuous flow to the process team leaders should make Value stream mapping (VSM), which is known as “material and information flow mapping” (Apel, et al., 2007). This tool is used to identify and potentially reduce wastes. It also aims to create continuous flow through the processes (Dennis, 2007).

VSM usually consist of five steps. Firstly the product or entity is identified. After the entity was chosen, a current VSM is constructed. Every step of the process should be mapped in VSM. Each step includes description of the cycle time, TAKT time, set up time, downtime, number of resources (workers), scrap rate and work in progress (WIP) (Apel, et al., 2007). This VSM should be analyzed in order to formulate problem areas and potential wastes to be reduced. It is done by defining value added steps. Then, after analyzing current state, a future state mapping is created and the plan is implemented (Hines and Rich, 1997).

VSM can be constructed using different software. One which came into widespread acceptance is this field is simulation software, for example, Arena, made by Rockwell Automation.

Supplier relationship system of TPS include Just-in-time delivery of supplies, quality assured supplies, single sourcing of supplies, supplier development activities, supplier involvement in design, reducing number of suppliers and financial stake in suppliers (Bicheno, 2000).

3.2.5.7. Standartization

5S is a strategy that delivers results by a systematic approach of planning and organizing the activities (Monden, 1994). 5S is a philosophy rooted from Japan and branched into other countries. 5S is an acronym for the following Japanese terms:

1. Seiri (Sort): Separate needed from unneeded items-tools, parts, materials, paperwork-and discard the unneeded.

2. Seiton (Set in order): Neatly arrange what is left in a place for everything and everything in its place.

3. Seiso (Shine): Clean and wash.

4. Seiketsu (Standardize): Cleanliness resulting from regular performance of the first three Ss.

5. Shitsuke (Sustain): Discipline, to perform the first four Ss.

Standardized work arises when the team members repeatedly follow the sequence of steps, which represent the "best practices" involved in completing the job, in order to reduce the variation performed by the employee. The main objective of standardized work is to eliminate waste and thus to achieve high productivity as during daily activities employees make many non-value added motions (Bicheno, 2000). In practice standardized work usually organized through the use of documented system, through which employees perform their tasks and record results.

3.2.5.8. Bundled techniques

Ahuja and Khamba (2008) defined TPM (Total Productive Maintenance) as a set of techniques, which is used to ensure that all equipment and machinery of the value creating process are at their optimum level of operational effectiveness. It has a high significant impact in improving the operational cost, high levels of quality and reliable delivery performance (Ahmed *et al.*, 2004)

Bakri et al. (2012) states that TPM is applied to the product produced, to the production process, to the environment in which the product is produced, to the management of the processes and to the level of the firm’s commitment to excellence.

Nakajima (1988) and Ahuja (2008) argue that the main objective of Total Productive Maintenance is to gain zero breakdowns, zero defects, zero accidents and zero waste. TPM requires cooperation inside and between all departments of the company

3.3. Lean implementation effectiveness evaluation

Lean implementation evaluation should be based on a set of special metrics. It should asses both tactical and strategic outcomes of Lean implementation (Doolen and Hacker, 2005). Ideal metrics should clearly direct decision-makers to corrective actions (Behrouzi and Wong, 2011). The assessment should be performed by an experienced team, but also external consultants’ involvement might also be necessary in order to provide an additional beneficial perspective in the planning stage.

In this research the metrics proposed by Nightingale (2005) consisting of four constitutes is analyzed. These four constitutes are strategy formulation, tactical metrics, operational metrics and value delivery metrics (see Figure 15).

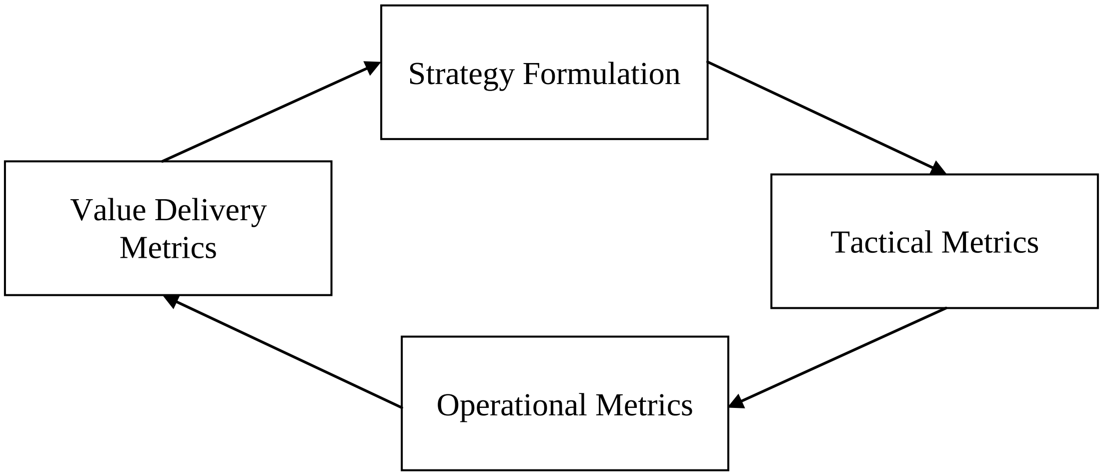

Figure 15. **A framework of metrics for Lean implementation initiatives assessment**

The issues which should be reviewed and tools for assessing Lean changes are presented in the Table 4.

Table 4. Lean evaluation metrics (Nightingale, 2005)

Type of metrics	**Reviewed issues**	**Tools**
Strategy formulation	– management assessment of competitive intelligence, – internal assessment, – strategic and operational planning assessment, – resource allocation plan;	– ROIC (Return invested capital), – economic value add (EVA), – net operating profit, – inventory turnover, – revenue, – cash flow and market position;
Strategy execution	– cascaded objectives, – VSM and project prioritization, – communication;	– financial turnover, – budget/cost, – expenses, – cost of quality, – productivity, – supply chain excellence, – regulatory, – social compliance indexes;

Operational Metrics	– balanced score cards – operations management, financial management, – human resource, – information systems;	– safety, – quality, – environment, – cost/manufacturing efficiency, – delivery, – time to market, – education and development, – time to market;
Value delivery metrics	– shareholder value, – customer satisfaction, – competition, – macro economic trends;	– stock price, – revenue, – on time delivery, – customer satisfaction , – loyalty, – employee satisfaction, – new product introduction;

Such framework proposed by Nightingale (2005) allows assessing changes in the company happened due to Lean implementation in holistic and comprehensive way.

4. EMPIRICAL STUDY

4.1. Explanation of the Variables and Methods used

Based on the literature review in Chapter 3, the list of variables, influencing the companies' willingness to implement TT projects was defined (Appendix 1). The corresponding indicators were extracted from the questionnaire and used in the analysis. The explanation of variables used in the analysis is also presented in Appendix 1.

Variables "Country", "Year", "Employees" and "Industry" are basic characteristics of the companies' participating in the survey. Variables "VDT61" – "VDT65" and "VDT71", "VDT72" reflect the companies' experience in TT projects experience, while variables "Ntused8" and "Lack9" describe the potential of the companies to participate in such projects. Variables "IT101" – "PEE106" show at which stages of TT projects in whole the problems are more likely to appear. Variables "IT111" – "AftTT176" represent the probability of concrete problems' occurrence at each stage of TT project. Variables "PrsSk181" – "Time2214" examine which factors related to internal environment of the companies have impact on implementation of TT projects. "Import23" is considering the respondents' opinion about the theme's importance and "Job25" represents respondents' positions in the companies.

For this study the analysis of means was chosen in order to define which problems in TT projects implementation do companies presented in the sample consider more or less possible. To determine if there any significant correlation between such variables as the age of the company and amount of employees and intensity of technology acquisition and commercialization processes cross-tabulation was used. After that, Two-way ANOVA analysis was chosen for examining the impact of firm's characteristics on its TT activities.

4.2. Current positions of the companies in TT projects implementation

Through the survey responses examination it emerged that the sample consists mostly of the companies which either already had experience in TT projects implementation or at least undertook some attempts in it.

The companies very seldom undertake activities in technology acquisition projects (mean =1,76) and even more seldom in technology commercialization projects (mean = 0,76). But at times these firms are still implementing some stages of TT projects, namely, they are searching for potential partners (mean = 2,38), scanning new technologies (mean = 3,33) and conducting negotiations with potential partners (mean = 3,6).

As for the companies' willingness to participate in TT activities, 83,33% of the firms noticed that they would like to participate in technology acquisition processes more actively. 80.95% pointed out that they would like to carry out technology commercialization activities more intensively. What is more, 57,14% of the companies already posses with not commercialized technologies (see Figure 16). And 59,5 % of the firms feel lack of new technologies (see Figure 17).

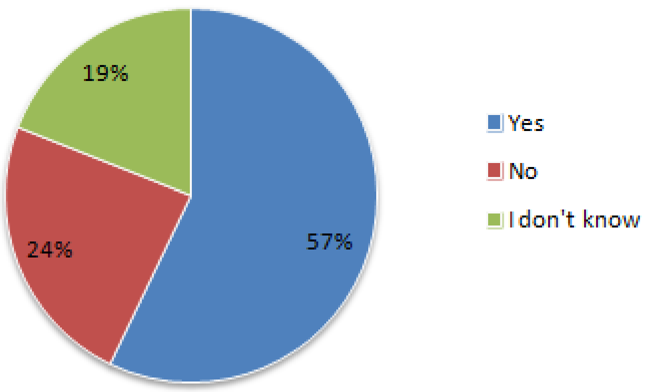

Figure 16. Pool of not commercialized technologies in the companies

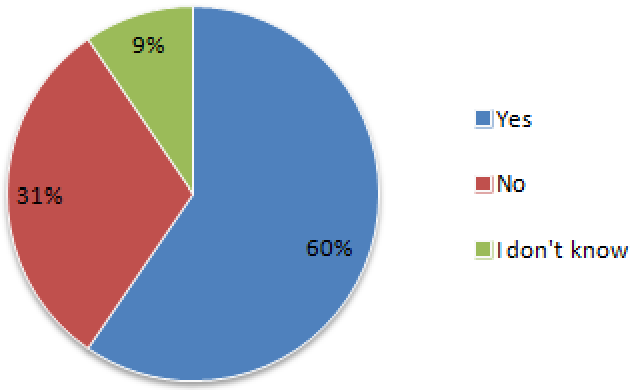

Figure 17. Lack of new technologies in the companies

Besides that, 95,24 % of the companies admit that TT topic is of current importance and it should be analyzed intensively.

As it turned out from Cross-tabulation analysis, if the company possesses with not commercialized technologies it doesn't mean that this company will participate actively in technology commercialization processes (Spearman Correlation = 0,018). And if the company lacks new technologies it doesn't mean that it will carry out intensive activities in technology acquisition projects (Spearman Correlation = 0,021). But if the company feels lack of new technologies it will more likely implement active partners' search (Spearman Correlation = 0,29) and scanning for new technologies (Spearman Correlation = 0,31).

4.3. Problems in TT projects implementation commonly faced by the companies

The firms participated in the survey were asked to evaluate the probability of problems' occurrence at each stage of TT project (see Figure 18).

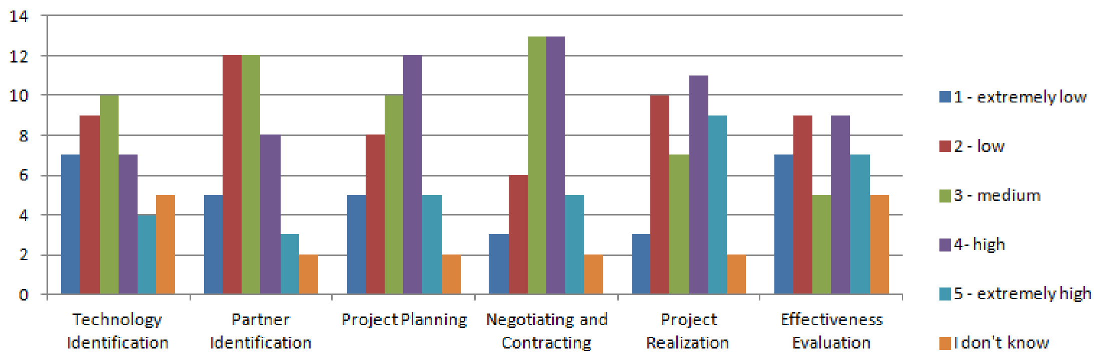

Figure 18. Probability of problems' occurrence at each stage of TT project

After that the companies were asked to evaluate which of the problems seems to them most probable to occur. The problems which got the highest estimations are presented in the Table 5.

Table 5. Problems most likely to occur during the stages of TT

Group	Sub-group	Problem	Mean
Process related	Technology identification stage	necessity of significant adaptation of the technology required	2,62
		to cope with the assets which the company possesses	2,5
		complexity of technology for understanding	2,24
		complexity of technology assimilation	2,2
	Partners Identification	complexity patent clearance evaluation	3,26
		mechanism of potential partners search may be not efficient enough	3,19
		personal interests, corruption may influence the decision making process about the partner	2,88
		inability to obtain all needed information	2,7
		small amount of partners available	2,68
	Of negotiations and contracting	marketing and product strategy	2,9
		differences in working methods and practices	2,88
		lack of trust	2,73
	Project planning	inaccurate estimation of firm's own capabilities	3,14
		unwillingness of the partner to provide all data required	2,97
	TT project realization stage	of the companies not to meet deadlines of start-up	3,66
		inability to meet planned production level	3,19
		failure to gain planned quality score	3,00

	TT project effectiveness evaluation	intents of the team to show better results then they are in reality looks very possible for the companies	3,43
		though absence of clearly defined mechanism for project effectiveness evaluation stays also important	2,97
	After the project	R&D spillovers is the main concern	2,93
		dependency on the partner	2,76
Corporate capabilities related	Problems with personnel and skills	not satisfied employees	3,19
		workforce not experienced and competent enough	2,95
		insufficient or ineffective trainings	2,88
	Problems with management	absence of clear defined procedures and instructions	3,05
		lack of experienced and committed top managers	3,02
		as the inadequate staff allocation for a project	2,78
		ineffective organizational structure	2,76
	Problems with communication and cooperation inside the firm	data is not available for everyone	2,9
		bureaucracy	2,83
		not all standards and procedures are determined clearly	2,69

Project planning stage is considered as the most difficult stage. However, the stages of negotiating and contracting, project effectiveness evaluation and partner identification remain to be considered as complicated ones.

At the first TT project stage, technology identification, necessity of significant adaptation of the technology required seems to the companies the most probable problem which can appear. Though such issues as necessity to cope with the assets which the company possesses, complexity of technology for understanding and complexity of technology assimilation remain extremely to be important issues which should be analyzed very carefully.

At the stage of partners Identification the complexity patent clearance evaluation, the mechanism of potential partners search may be not efficient enough, personal interests, corruption may influence the decision making process about the partner looks more dangerous issues. Though such issues as inability to obtain all needed information and small amount of partners available stay something like important.

At the stage of negotiations and contracting inability to come up with agreement about the price, marketing and product strategy, differences in working methods and practices and lack of trust are the most dangerous moments.

At Project planning leaders are inaccurate estimation of firm's own capabilities and unwillingness of the partner to provide all data required.

At TT project realization stage concerns of the companies not to meet deadlines of start-up, inability to meet planned production level and failure to gain planned quality score.

At the stage of TT project effectiveness evaluation the intents of the team to show better results than they are in reality looks very possible for the companies. Though the absence of clearly defined mechanism for project effectiveness evaluation stays also important.

After the project possibility of R&D spillovers occurrence is the main concern, while dependency on the partner remains quite possible problem.

Among corporate capabilities related issues the companies emphasized problem of not satisfied employees, not enough high level of workforce's experienced and competences, insufficient or ineffective trainings, absence of clear defined procedures and instructions, lack of experienced and committed top managers, inadequate staff allocation for a project, ineffective organizational structure, low availability of data, bureaucracy and poor definition of standards and procedures.

The companies were asked to evaluate the measure to which the costs arising during TT project should be reduced (- 2 – should be reduced significantly, 0 – may stay as they are, 2 – may be increased). The results are presented in the Table 6.

Table 6. The main TT project costs which should be reduced

Group	Types of costs	Mean
The costs associated with TT projects	Transportation costs should be reduced	-0,09
	Assets rent / purchasing	0,38
	Software licenses	0,31
	Costs of trainings, meetings and events	0,33

The companies were asked to evaluate the probability of stoppages occurense during TT project (Likert scale). The results are presented in the Table 7.

Table 7. The most probable stoppages during TT project

Group	Types of costs	Mean
The probability of the stoppages occurrence during TT project realization	Project planning	3,17
	Personnel trainings to required level of expertise	3,09
	Contracting with partner	2,83
	Negotiations with the partner	2,76

4.4. Correlations between variables

According to the cross-tabulation, companies operating in the market for the longest time used to participate in external technology acquisition projects more intensively (Pearson's R = -0,7). There is also strong correlation between the companies' age and amount of not commercialized technologies which it possesses (Pearson's R = -0,64)

The age of the company influences the frequency of technology external commercialization. Older companies perform these activities more often (Pearson's R = -0,27). The same influence the companies' age has on intensity of participating in partners' search (Pearson's R = -0,22) and on intensity of negotiations conducting (Pearson's R = -0,25).

The size of the company has a strong positive impact on technology acquisition activities (Pearson's R = 0,52), technology commercialization activities (Pearson's R = 0,4) and partners search (Pearson's R = 0,3).

As it turned out, the industry in which the company operates plays an important role in defining technology transfer activities (see Appendix 2). The highest percentage got the companies from chemical industry (66,7%) and hardware and equipment (28,6%). Both of these industries often undertook activities in technology acquisition processes very intensively.

Furthermore, software and hardware and equipment companies participate in technology commercialization activities (26,7%) more often than companies operating in another fields.

In partners search participate intensively companies from household (100%), consumer durabels (50%), software (33,3%), and materials (25%). Hardware and equipment participate intensively (28,6%) and often (42,9%) and companies from energy field (16,7%- intensively, 33,3% - often).

Technology scanning is more often performed by the companies from software (83,3%) energy (66,6%), materials (50%), hardware and equipment (42,9%) and chemicals industries (33%).

Negotiations are more often performed by chemical (100%), commercial and services (100%), software (83,3%), hardware (57%), energy (50%), materials (50%), consumer durabels and apparel (50%), real estate (40%).

4.5. ANOVA

According to findings, the year in which the company was established more influence International Innovators (mean 3,3) compare to Domestic Innovators (mean 2,5), Domestic non innovators (mean 2,8) and International non innovators (mean 2,5). Amount of employees working in the company has impact on Domestic non innovators (mean 3,5) and International Innovators (mean 3,6) rather, than on International non innovators (mean 2,9) and Domestic Innovators (mean 3,1).

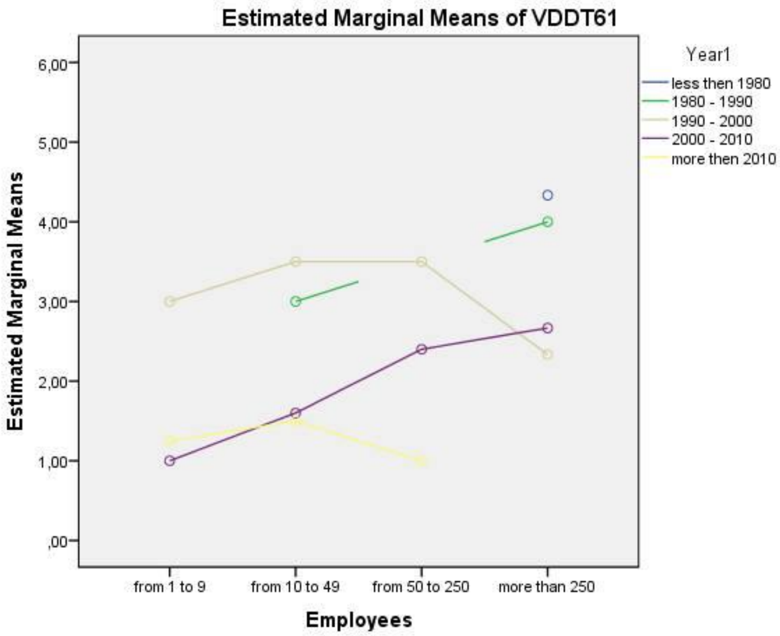

Figure 19. Intensity of Technology acquisition processes presented for the companies of different size and age

According to the graph, the distance is high between different age groups of the companies regarding to the acquisation. The numerical values are higher for old companies than for more young companies. Also the graph shows little difference in acquisation regarding to number of employees.

It can be finalised, the year (age of the company) will have statistically significant influence on technology acquisition processes of the company (F = 4,424, Sig. = 0,007) while amount of employees will not have insignificant influence (F = 0,334, Sig. = 0,801).

In addtition, there was also found out significant influence of amount of employees on partner search frequency (F = 3,55, Sig. = 0,027)

5. LEAN IMPLEMENTATION MODEL OF TECHNOLOGY TRANSFER PROJECT

5.1. Framework for TT projects transformation via Lean principles

The proposed implementation framework (see Figure 20) aims to overcome the limitations of the existing frameworks and, subsequently, to achieve practicality of Lean implementation for effective TT projects realization. The project process framework can contribute to the accomplishment of the objective addressed. The processes permit lean implementation to be established in sequences from the conceptual phase to the phase of completion of lean transformation.

Proposed implementation framework consists of five phases, which are conceptualization phase, implementation design phase, TT preparative phase, implementation phase and Evaluation and transformation phase. These phases are explained in details in the next sections.

5.1.1. Conceptualisation phase

Conceptualization is the phase, which selects, widens scope and trains the personnel involved in the lean implementation. The principal data, information, and knowledge of Lean are transferred to the team.

In the beginning the team is formed, it understands specific organizational characteristics, reviews lessons learned frm previous projects (if it is not the first time). After this benefits of Lean to the organization should be explored to make each member aware of why the Lean implementation project is important. Enhancement of mind-set and deep understanding of Lean concept is expected after this phase.

The intra communication channels should be established. After this the team can start to review potential wastes and techniques which can be used to reduce them. The last step of this phase is definition of the metrics for future project effectiveness evaluation.

5.1.2. Implementation design phase

Implementation design phase designs the Lean plan and prepares the Lean team to the practice. This phase identifies the organizational Lean current state and requirements through various analyses. The recommended tools for this phase mainly emphasise on decision-making process to deliver successful Lean implementation.

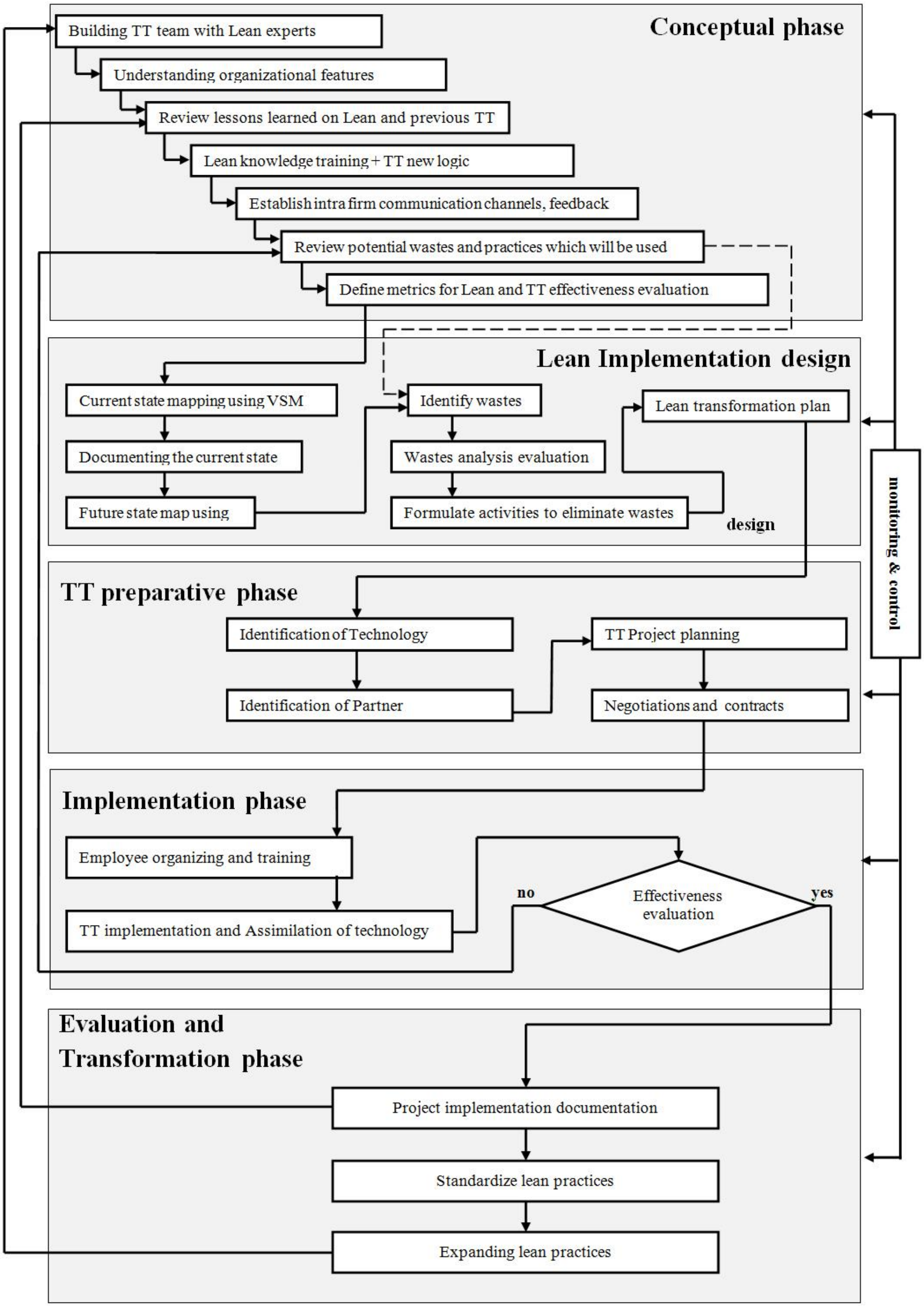

Figure 20. Framework for TT projects transformation via Lean principles

In the beginning current state is mapped using VSM. Work sampling is a statistical-based method which can be used for evaluating the physical work. It determines the relative amount of time spent on various tasks through site observation. After this the current state is documented. Future state mapping is organized on the basis of comprehensive analysis of the sequence of processes. All types of existing wastes are identified, evaluated, appropriate techniques for these wastes elimination are chosen. A cause and effect diagram can be used to understand the main causes of each waste type. These causes are generally grouped as manpower, machine, material, method and measurement. The final step of this phase is complete plan of Lean transformation.

5.1.3. TT preparative phase

At the stage of technology identification the special team is formed. It makes a list of technologies with description of its potential, estimates potential market share, attractiveness of the end product to a customer, evaluates resources and complementary assets needed for successful transfer / assimilation of technology, evaluates technological risks, confirms chosen technologies at corporate level.

At the stage of partner identification the team makes a list of possible potential partners. External and internal environment of a partner are carefully analyzed. All possible strategic and economic outcomes of the partnership are formulated.

While implementing the stage of negotiations and contracting the companies should come to agreement about the price, amount and frequency of payments, TT mechanism, communication channels, degree of parties involvement, amount and frequency of trainings, etc.

TT project planning stage, which is considered to be the most timeconsuming, includes all planned activities scheduling, trainings preparation, organizational structure of the company may be reconstructed, IP protection clearance is assured.

5.1.4. Implementation and evaluation phase

This is the execution phase, which delivers and evaluates the Lean plan. The implementation process starts with employee organization and trainings, then actual Transfer of Technology is realized through all the processes defined in VSM in defined sequence. TT realization stage's main operations are personnel allocation, trainings on defined schedule and quality, incentive system organization, contracting suppliers of spares, equipment and services, physical transactions, assimilation in defined deadlines, quality management, etc.

TT project evaluation is extremely complex task because there is variety of possible outcomes such as economic, social, administrative, institutional, political and process-related results. It can be done with accordance to reviewed strategic and economic outcomes.

An implementation evaluation of Lean can be done using the metrics and the sources of information proposed in the Table 4.

5.1.5. Complete Lean transformation phase

This is the final phase documenting the new lessons learned and scope changes resulted during execution, establishment of new Lean standards and planning of continuous improvement. To accomplish Lean transformation, the organization must ensure that all necessary changes to the established requirements are implemented. This process aims to optimize the results of lean practice prior to the process of standardization or future utilization of the practice. Expanding the scope of lean implementation is an indicator of continuous improvement whereas stakeholder's involvement at all levels must be included.

Monitoring and controlling process is integrated to all phases to ensure that the expected results towards Lean Technology Transfer transformation are completely delivered.

The monitoring and controlling process recommends preventive actions for any unanticipated situations. Moreover, it allows any influencing factors in lean implementation to be identified. Monitoring and controlling include measuring of the actual Lean accomplishment and comparing with the lean transformation plan. The absence of monitoring and controlling on Lean implementation results in failures of the lean transformation.

5.2. Addressing main challenges of TT project implementtation

During Technology Identification stage the necessity of significant adaptation of the technology required and inability to cope appropriately with the assets which the company possesses were important problems which companies face. These issues are addressed at the phase of Lean implementation design. While mapping current state the company becomes able to understand what are the weakest points in the current processes sequence, using statistical-based methods of work sampling. It will make the process of Technology Transferred visible. It will also provide the companies with an opportunity to evaluate properly the assets possessed in order to build adequate future state mapping for its exploitation.

Other important issues to be addressed are complexity of technology for understanding and complexity of technology for assimilation. These issues are related to organizational Lean learning which implies the development of increasingly efficient routines while problem solving processes. The knowledge acquired through the problem solving situations are standardized and thus can be used in the next project implementation. This concept also solves the mentioned problems of workforce not experienced and competent enough. Another thing which contributes to organizational learning is job rotation which provides the employees with deep understanding of different aspects of technology and its assimilation and commercialization processes. 5 Why concept allows the employees to understand the root problems of any problems occurrence. It means that both complexity of technology for understanding and for assimilation problems have the root cause problem. With its clear formulation the solution of this problem can be easily defined. TPM will contribute to technology assimilation processes by avoiding different types of wastes which may occur. Pokayoke promotes to prevent potential defects which may arise during assimilation process.

The companies commonly face the problems with defining the appropriate mechanism of Technology Transfer and with defining an appropriate mechanism for partners search. These problems again deal with Lean organizational learning. VSM will provide the companies with the possibility to define ideal future state mapping of TT mechanism chosen, which will also solve the problem of low efficiency of current TT mechanism by changing the sequences of the processes and elimination of wastes in each step.

During the stage of negotiations with the partners the companies emphasized the problem about inability to obtain needed information from the partner. Lean implies that during Technology Transfer project the partners' relationships impose duties upon both parties to deliver all required information, to make it visible and educe possible barriers to required data gathering.

At this stage the companies state that often it is difficult to cooperate with the partner due to existing differences in working methods and practices and to lack of trust between the parties. While adopting Lean concept to TT project via proposed framework the company at least from its side is ready to adjust its processes and working methods to suit concrete project requirements.

At the most difficult from the point of companies' view, the project planning stage, the companies have concerns about inaccurate estimation of firm's own capabilities. This problem can be entirely solved by adopting Lean principles as definition of the firms capabilities is in the focus of VSM processes.

During the stage of TT realization the companies are beware of the possibility not to meet deadlines of start-up, not to meet planned production level and not to gain planned quality score. These issues are directly in the focus of Lean concept. Just-in-Time pull production implies that everything is produced exactly in required amount and to required moment. The advantages of such system are intensified by implementing Kaizen, with its continuous improvements of the process, and 5S concept, helping to reduce wastes during the project.

The fear of the companies not to find an appropriate mechanism for project effectiveness evaluation is eliminated by two proposed mechanisms of TT project and Lean initiatives implementation effectiveness evaluation.

The problems of low employees satisfaction, ineffective trainings and inability to get required information can be entirely solved by shifting into practice the basic values of TPS.

Also, by implementing Lean concept the companies will solve the problems of poor definition of all procedures and instructions.

All costs which can be referred to as wastes as well as all the stoppages as a form of timing wastes can be eliminated through Lean principles adoption.

6. CONCLUSIONS

The main aim of the research was to understand if Lean management principles can be applied in TT projects in order to solve the problems arising during its implementation and how. Extensive analysis of the scientific literature allowed identify a variety of issues which may deter the companies from implementing TT projects. The most frequently mentioned problems were evaluated by interviewing the companies from the sample selected. On the ground of comprehensive analysis of the literature about Lean management, its competitive advantage and its applicability, it was checked if Lean principles are able to solve the most commonly faced by responded companies problems. It was found out that almost all detected problems can be solved through the use of Lean concept adoption to the higher or lower extent. According to the findings the problems related to corporate capabilities issues and the problems arising from the presence of wastes can be solved by the use of Lean management to a higher degree than problems related to communication with external party.

Secondly, in order to solve the problem of clear guidance lack about TT projects implementation the project based framework for TT projects transformation via Lean principles was proposed. This conceptual framework should be further development and empirically tested.

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APPENDIXES

Appendix 1. Variables, used in SPSS analysis

Variable	Explanation	Measurement (scale)	Variable	Explanation	Measurement (scale)
Country	Location of the company	Nominal	PR156	Probability of inability to meet deadlines	Likert scale (1-5)
Year	Year in which the company was established	Ordinal (1-5)	PEE161	Probability of absence of clearly defined mechanism for project effectiveness evaluation	Likert scale (1-5)
Employees	Amount of employees	Ordinal (1-4)	PEE162	Probability of intents to show better results then in reality	Likert scale (1-5)
Industry	industry which represents the biggest share of the company's revenues	Ordinal (1-24)	AftTT171	Probability of market share loss	Likert scale (1-5)
VDDT61	Frequency of complete external technology acquisition implementation	Ratio scale (0-5)	AftTT172	Probability of dependency on the partner	Likert scale (1-5)
VDDT62	Frequency of technology commercialization implementation	Ratio scale (0-5)	AftTT173	Probability of detrimental effect on position in industry	Likert scale (1-5)
VDDT63	Frequency of partners' search imlementation	Ratio scale (0-5)	AftTT174	Probability of R&D spillovers	Likert scale (1-5)
VDDT64	Frequency of new technologies search	Ratio scale (0-5)	AftTT175	Probability of loss of the customer loyalty	Likert scale (1-5)
VDDT65	Frequency of negotiations implementation	Ratio scale (0-5)	AftTT176	Probability of core business suffered (R&D, production, etc.)	Likert scale (1-5)
VDDT71	Measure to which external technologies acquisition should be increased / decreased	Ratio scale (-2-2)	PrsSk181	Probability of workforce not experienced and competent enough	Likert scale (1-5)

VDDT72	Measure to which external technologies commercialization should be increased / decreased	Ratio scale (-2-2)	PrsSk182	Probability of insufficient or ineffective trainings	Likert scale (1-5)
Ntused8	Unrealized technologies presence	Nominal (yes – no)	PrsSk183	Probability of not-invented-here syndrome	Likert scale (1-5)
Lack9	New technology shortage	Nominal (yes – no)	PrsSk184	Probability of not satisfied employees	Likert scale (1-5)
IT101	Probability of the problem occurrence on the stage of technology identification	Likert scale (1-5)	Mang191	Probability of lack of experienced and committed top managers	Likert scale (1-5)
IP102	Probability of the problem occurrence on the stage of partner identification	Likert scale (1-5)	Mang192	Probability of absence of clear defined procedures and instructions	Likert scale (1-5)
NC103	Probability of the problem occurrence on the stage of negotiations and contracting	Likert scale (1-5)	Mang193	Probability of inadequate staff allocation for a project	Likert scale (1-5)
PP104	Probability of the problem occurrence on the stage of Project Planning	Likert scale (1-5)	Mang194	Probability of ineffective organisational strcture	Likert scale (1-5)
PR105	Probability of the problem occurrence on the stage of Project Realization	Likert scale (1-5)	Intracom201	Probability of not all standards and procedures are determined clearly	Likert scale (1-5)
PEE106	Probability of the problem occurrence on the stage of Project Effectiveness Evaluation	Likert scale (1-5)	Intracom202	Probability of ineffective use of software for communication between employees	Likert scale (1-5)
IT111	Probability of being locked on complementary assets	Likert scale (1-5)	Intracom203	Probability of complicated data storage	Likert scale (1-5)
IT112	Probability of high complexity of technology	Likert scale (1-5)	Intracom204	Probability of data is not available for everyone	Likert scale (1-5)
IT113	Probability of high complexity of assimilation	Likert scale (1-5)	Intracom205	Probability of language, cultural, personal barriers	Likert scale (1-5)
IT114	Necessity of	Likert	Intracom206	Probability of	Likert scale

	significant adaptation to local conditions	scale (1-5)		bureaucracy	(1-5)
IT115	Probability of questionable patent clearance	Likert scale (1-5)	Cost211	Measure to which assets rent / purchaising should be reduced	Ratio scale (-2-2)
IT116	Probability of the obsolescence of technology for the time of TT	Likert scale (1-5)	Cost212	Measure to which materials and components should be reduced	Ratio scale (-2-2)
IT117	Probability of corruption in the choice of technology	Likert scale (1-5)	Cost213	Measure to which wages of managers, workforce should be reduced	Ratio scale (-2-2)
IP121	Probability of corruption in partner's choice	Likert scale (1-5)	Cost214	Measure to which software licenses should be reduced	Ratio scale (-2-2)
IP122	Probability of unreliable data gathered about the partner	Likert scale (1-5)	Cost215	Measure to which transportation costs should be reduced	Ratio scale (-2-2)
IP123	Probability of small quantity of partners available	Likert scale (1-5)	Cost216	Measure to which costs of trainings, meetings and events should be reduced	Ratio scale (-2-2)
IP124	Probability of not effective mechanism of partner search	Likert scale (1-5)	Cost217	Measure to which partner search associated costs should be reduced	Ratio scale (-2-2)
IP125	Probability of too complicated communication with possible partner	Likert scale (1-5)	Time221	Probability of stoppages occurrence in technology concept development	Likert scale (1-5)
NC131	Probability of differences in negotiation approaches and strategies	Likert scale (1-5)	Time222	Probability of stoppages occurrence in technology search and evaluation	Likert scale (1-5)
NC132	Probability of differencies in working methods	Likert scale (1-5)	Time223	Probability of stoppages occurrence in corporate level confirmations	Likert scale (1-5)
NC133	Probability of differences in culture	Likert scale (1-5)	Time224	Probability of stoppages occurrence in partners search and evaluation	Likert scale (1-5)

NC134	Probability of goal incompatibility during negotiations	Likert scale (1-5)	Time225	Probability of stoppages occurrence in negotiating the partner	Likert scale (1-5)
NC135	Probability of inability to come up with agreement about the price, marketing and product strategy	Likert scale (1-5)	Time226	Probability of stoppages occurrence in contracting with partner	Likert scale (1-5)
NC136	Probability of lack of trust	Likert scale (1-5)	Time227	Probability of stoppages occurrence in IP rights protection	Likert scale (1-5)
NC137	Probability of not effective communication channels	Likert scale (1-5)	Time228	Probability of stoppages occurrence in planning	Likert scale (1-5)
PP141	Probability of not effective communication between partners	Likert scale (1-5)	Time229	Probability of stoppages occurrence in stoppages in supplies of components	Likert scale (1-5)
PP142	Probability of low partner involvement in planning	Likert scale (1-5)	Time2210	Probability of stoppages occurrence in transportation	Likert scale (1-5)
PP143	Probability of unwillingness of the partner to provide all data required	Likert scale (1-5)	Time2211	Probability of stoppages occurrence in equipment adjusting	Likert scale (1-5)
PP144	Probability of inaccurate estimation of firm's own capabilities	Likert scale (1-5)	Time2212	Probability of stoppages occurrence in adaptation the processes to local conditions	Likert scale (1-5)
PR151	Probability of high costs and low quality of local suppliers of products and services	Likert scale (1-5)	Time2213	Probability of stoppages occurrence in personnel trainings	Likert scale (1-5)
PR152	Probability of inadequate monitoring and control	Likert scale (1-5)	Time2214	Probability of stoppages occurrence in effectiveness evaluation	Likert scale (1-5)
PR153	Probability of inability to hold	Likert scale (1-5)	Import23	Importance of the topic	Nominal

	scheduled trainings				
PR154	Probability of failure to gain planned quality score	Likert scale (1-5)	Job25	Position in the company	Nominal
PR155	Probability of inability to meet planned production level	Likert scale (1-5)			

Appendix 2

Intensity of external technology acquisition projects

Industry * VDDT61 Crosstabulation							
% within Industry							
Industry		VDDT61					
		I dont know	Very seldom	Seldom	From time to time	Often	Intensively
	Energy	16,70%		33,30%	33,30%	16,70%	
	Materials		100,00%				
	Consumer durabelsa and apparel		50,00%			50,00%	
	Commercial and prof services					100,00%	
	Chemical		33,30%				66,70%
	Hotels restaurants		100,00%				
	Household				100,00%		
	Health care				100,00%		
	Financials				100,00%		
	Real estate	20,00%	60,00%			20,00%	
	Software		16,70%	50,00%	33,30%		
	Hardware and equipment				42,90%	28,60%	28,60%
	25		25,00%		50,00%	25,00%	
Total		4,80%	28,60%	11,90%	28,60%	16,70%	9,50%

Intensity of external technology commercialization projects

Industry * VDDT62 Crosstabulation						
% within Industry						
		VDDT62				Total
		0	Very seldom	Seldom	From time to time	
Industry	Energy	60,00%	20,00%	20,00%		100,00%
	Materials	75,00%		25,00%		100,00%
	Consumer durabelsa and apparel	50,00%		50,00%		100,00%
	Commercial and prof services		100,00%			100,00%
	Chemical	66,70%	33,30%			100,00%
	Hotels restaurants	100,00%				100,00%
	Household	100,00%				100,00%
	Health care	100,00%				100,00%
	Financials	100,00%				100,00%
	Real estate	80,00%	20,00%			100,00%
	Software	50,00%	16,70%	16,70%	16,70%	100,00%
	Hardware and equipment	14,30%	14,30%	57,10%	14,30%	100,00%
	25	50,00%	25,00%	25,00%		100,00%
Total		56,10%	17,10%	22,00%	4,90%	100,00%

Intensity of partners search activities

		VDDT63						Total
		0	Very seldom	Seldom	From time to time	Often	Intensively	
Industry	Energy	33,30%			16,70%	33,30%	16,70%	100,00%
	Materials	25,00%	25,00%	25,00%			25,00%	100,00%
	Consumer durabelsa and apparel	50,00%				50,00%		100,00%
	Commercial and prof services			100,00%				100,00%
	Chemical	33,30%		66,70%				100,00%
	Hotels restaurants		100,00%					100,00%
	Household						100,00%	100,00%
	Health care		100,00%					100,00%
	Financials	100,00%						100,00%
	Real estate	40,00%		20,00%	20,00%	20,00%		100,00%
	Software	50,00%			16,70%		33,30%	100,00%
	Hardware and equipment	14,30%		14,30%		42,90%	28,60%	100,00%
	25	25,00%				50,00%	25,00%	100,00%
Total		31,00%	7,10%	14,30%	7,10%	21,40%	19,00%	100,00%

Intensity of scanning for new technologies

		VDDT64					Total
		0	Seldom	From time to time	Often	Intensively	
Industry	Energy	16,70%			50,00%	33,30%	100,00%
	Materials		50,00%		25,00%	25,00%	100,00%
	Consumer durabelsa and apparel	50,00%		50,00%			100,00%
	commercial and prof services				100,00%		100,00%
	Chemical		33,30%		33,30%	33,30%	100,00%
	Hotels restaurants			100,00%			100,00%
	Household			100,00%			100,00%
	Health care		100,00%				100,00%
	Financials			100,00%			100,00%
	Real estate	40,00%	20,00%	20,00%	20,00%		100,00%
	Software		16,70%			83,30%	100,00%
	Hardware and equipment	14,30%		28,60%	14,30%	42,90%	100,00%
	25			50,00%	25,00%	25,00%	100,00%
Total		11,90%	14,30%	21,40%	21,40%	31,00%	100,00%

Intensity of negotiations

		VDDT65						Total
		0	Very seldom	Seldom	From time to time	Often	Intensively	
Industry	Energy	33,30%				16,70%	50,00%	100,00%
	Materials			25,00%	25,00%	25,00%	25,00%	100,00%
	Consumer durabelsa and apparel	50,00%					50,00%	100,00%
	commercial and prof services						100,00%	100,00%
	Chemical					33,30%	66,70%	100,00%
	Hotels restaurants				100,00%			100,00%
	Household					100,00%		100,00%
	Health care			100,00%				100,00%
	Financials					100,00%		100,00%
	Real estate		40,00%	20,00%		20,00%	20,00%	100,00%
	Software		16,70%				83,30%	100,00%
	Hardware and equipment	14,30%			28,60%	14,30%	42,90%	100,00%
	25					75,00%	25,00%	100,00%
Total		9,50%	7,10%	7,10%	9,50%	23,80%	42,90%	100,00%