Kaunas University of Technology

School of Economics and Business

Uneven Diffusion of Lean Methods in Lithuania: The Case Company's Export Extent, Sector and Size

Master's Final Degree Project

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Kaunas, 2021

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Summary

As the manufacturing industries are trying to achieve greatness in terms of customer satisfaction and a better competitive spot in the specific industry. The lean methods and policies are one of the main tools to improve the manufacturing cycles for better results. Companies these days are trying to improve the efficiency of the manufacturing flow, better delivery accuracy, and also to create the bigger value with less waste to use. Lean methods are the straight path to a more productive manufacturing environment.

This master thesis aims to identify and use the research model, provide the results of lean methods diffusion. The first part of the thesis has analyzed the literature to identify the problem of the lean methods diffusion in the producing companies. The disadvantages the diffusion brings for the companies and countries and the factors that lead companies to the diffusion of lean methods. The second part of this research consists of the theoretical analysis in which analyzed the lean production methods,- the benefits of the lean methods. The factors that influence companies to innovate and pursue the top place of the competition are export activities, size of the company, and the sector the companies are working in. The third part of the thesis is about the reserach methodology, the methods used, and the SPSS program usage. The final part of the research project analyzed lean methods, the value added to the companies and how the included factors interface with the lean production methods- how they determine lean methods diffusion.

The main object of this research is to identify, what is the lean methods diffusion in Lithuania industry and identify the main factors determining the diffusion (export, organizational size, and sector)

The main research problem is to determine the current situation of lean methods diffusion in Lithuania and to outline the elements that influence the uneven diffusion

The main research question – how the selected factors influence the spread of lean methods in Lithuania?

Research results part: the quantitative research method was used to analyze the data collected in the telephone survey about the manufacturing companies, secondary data analysis was done for collected data

Julius Jurgelaitis. Netolygi “Lean” metodų sklaida Lietuvoje atsižvelgiant į įmonių eksporto apimtis, sektorius ir dydį.Magistro baigiamasis projektas / vadovas prof. dr. Mantas Vilkas; Kauno technologijos universitetas, Ekonomikos ir verlo fakultetas.

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Santrauka

Kai gamybos pramonė stengiasi pasiekti didesnį klientų pasitenkinimo lygį ir išslaikyti konkurencingumą konkrečiame pramonės sektoriuje. „lean“ metodai ir jų politika yra viena iš pagrindinių priemonių pagerinti gamybinių procesų ciklus, kad būtų pasiekti geresni rezultatai. Būtent dabartiniais laikais įmonės bando pagerinti gamybinių srautų efektyvumą, tikslenį pristatymo laiką ir sukurti didesnę produkto vertę sumažinat išlaidas. „lean“ metodai yra tiesus kelias į produktyvenę gamybinę aplinką.

Šio magistro darbo pagrindinis tikslas yra suformuluoti modelį ir jo pagalba pateikti „lean“ metodų sklaidos rezultatus. Pirma darbo dalis sudaro literatūros analizė, siekiant nustatyti „lean“ metodų netolygią sklaidą gamybos įmonėse. Sklaidos trūkumai , kurie iššaukia problemas kompanijoms ir šalims kruriose jos daro savo veiklą faktorius kurie veda prie „lean“ metodų netolygios sklaidos. Antrą šio tyrimo dalį sudaro teorinė analizė, kurios metu buvo analizuojami „lean“ gamybos metodai, jų nauda. Surasti pagrindiniai veiksniai kurie skatina įmones diegti naujoves ir sikti auksčiausios konkurencingos vietos : eksporto veikla, įmonės dydis ir įmonės sektorius. Trečioje darbo dalyje yra kalbama apie tyrimo metodiką, naudotus metodus ir SPSS programos naudą. Paskutinėje tyrimo dalyje buvo išnalaizuoti „lean“ metodų naudojimas, vertė kurią sukuria metodų naudojimas ir kaip išskirti veiksniai sąveikauja „lean“ gamybos metodais, kaip jie lemia metodų sklaidą.

Pagrindinis šio tyrimo tikslas yra nustatyti, kokia yra „lean“ metodų sklaida Lietuvos industrijoje ir identifikuoti pagrindinius faktorius nulemiančius tą sklaidą

Pagrindinė tyrimo problema yra nustatyti dabartinę „lean“ metodų sklaidą lietuvoje ir išanalizuoti elementus kurie daro įtaką netolygiai sklaidai.

Pagrindinis tyrimo klausimas yra nustatyti kaip atrinkti faktoriai daro įtaką „lean“ metodų sklaidai Lietuvoje?

Tyrimo rezultatų dalis parodo, kad darbas yra kiekybinis tyrimo metodikos, metodas buvo naudojams išanalizuoti telefonu sutinktos apklausos duomenis apie gamybines įmones, antrinė duomenų analizė surintiems duomenims.

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INTRODUCTION

Lean methods are widely adopted by organizations. Lean is associated with competitive advantage allowing companies to decrease costs and increase customer value. The term "Lean" was used to characterize the Toyota production system. In the 1988, the term "Lean" was popularized by the researcher (vardą reikią įdėti) Krafric. (Luis Lopes, 2019). Womack et. (1990, 1996) proposed which methods constitute lean. Further (Shah and Ward, 2007) proposed that lean production consists of internally related methods, supplier-related and customer-related methods. Lean methods were researched from various aspects. Lean adoption drivers, implementation barriers, and the effects of Lean adoptions ware at the center of the research of Lean production.

The adoption drivers are motivations that drive companies to adopt lean production (F.Abu, H.Gholami,M.Z. Mat Saman, N. Zakuan, D. Streimikiene 2019). Research reveals that efficiency, problem solving, improvement of the organization, customer satisfaction, and profit increase constitute the main motives of Lean adoption in Lithuania. (M.Vilkas, I.Koreckaja, E.Katiliūtė, D.Bagdonienė 2015).

There is also extensive research about the barriers and challenges of Lean adoption. People and partner disagreements, managing and organizing problems, the shortage of commitment and support barriers, cultural barriers, and the problems related with the government obstacle the adoption of Lean (G.Shang, L.S. Pheng, 2014) are: The effects are usually being evaluated the ones like motives, that stimulated companies to adopt lean and give a result which is positive or negative. The example was done on the research to improve the turnaround time to minimize it to a lower period of time (P. Hwang, D. Hwang. P. Hong 2014). The effects could be different and unique based on the companies, which the organization wants to improve with lean methods.

Despite previous research, little is known about the diffusion of Lean production methods among production companies: which production companies use Lean methods more extensively. Studies that analyze the diffusion of Lean methods usage among manufacturing companies in Lithuania and abroad are rare. The diffusion of the Lean methods would help understand what kind of manufacturing companies use Lean methods more extensively.

First, there no research if exporting companies use Lean methods more extensively comparing to non-exporting companies. It is known that companies that work together in a supply chain tend to exchange information on how to improve the flow of information and goods. This is why exporting companies that do collaborate with the companies who use lean methods are more likely to adopt those methods to increase the efficiency for both companies and build a strong relationship. In addition, I will try to seek to understand which other factors, such as the size of the organization and sector, contribute to the uneven diffusion of Lean methods.

Research question. Whether lean methods are more extensively adopted by exporting companies comparing with non-exporting companies? Whether other factors, such as size and sector, influence the difference of diffusion of Lean methods?

Research aim. Determine whether there are differences in the adoption of lean methods depending on the company's involvement in exports, size of the organization, and sector.

Research object. Diffusion of lean production methods in Lithuania.

Objectives of the research:

1. Conduct literature analysis that would reveal local and global diffusion of lean production methods. (1. Problem analysis).
2. Ground factors that do influence the uneven diffusion of lean production in Lithuanian. (2. Literature analysis).
3. Ground the methodology that would allow to reveal diffusion of lean production methods in Lithuania. (3. Methodology).
4. Present the findings revealing the diffusion of lean production methods in Lithuania. (4. Results).

Methods.

The literature review and an analysis of secondary data were used to achieve the thesis goals. The study of the literature used to expose the local and global dissemination of lean production methods.

The empirical part is based on the analysis of secondary data of the European manufacturing survey conducted in Lithuanian in 2018 (M. Vilkas et al. 2019). The telephone survey was used to implement European manufacturing survey in Lithuania. The stratified random sampling was used to sample manufacturing organizations participating in the survey. Strata has been specified in terms of four regions of the country and four organizational categories of scale. 2330 manufacturing companies were contacted The effective sample consists of 500 manufacturing sites, which reflects a response rate of 21.45 per cent of all manufacturing sites that were contacted.

Structure of the thesis.

In the first part of the thesis, the lean production paradigm and the diffusion of lean methods locally and globally are reviewed. In the second part, lean production methods are presented, the hypotheses grounding the influence of a company‘s involvement in export, size of the organization, and sector on the diffusion of lean production methods are grounded. The third part is devoted to the description of the methodology that was used to determine if there if exports, organizational size, and sector determine the uneven diffusion of lean methods. In the last part of the thesis, the results of empirical analysis are presented.

1. THE LITERATURE ANALYSIS OF LEAN

1.1. Lean concept

In today's manufacturing industry, probably all companies did hear or had some interaction with a concept of lean, as like 2005 it was said by T.Melton (2005) that not many people in the industry of manufacturing could genuinely say that they never heard of lean. It is known that the concept ''Lean'' was firstly mentioned by Krafcik in 1988 (Krafcik,1988), which idealized and wanted to break myths about the auto industry and its productivity, efficiency, and waste constants.

The concept of lean has usually related to efficiency and waste. Waste is the process that gives no value to the companies manufacturing flow or the employees' work ethics seeking to improve the manufacturing time, quality of the product, or the service company is providing to the customer (Shah and Ward, 2007). It has been found, that almost 50 percent of the working time employees have, they usually waste it activities that do not bring any significant value to the company, such as waiting for the arriving material stuck in traffic or making decisions more (Diekmann, 2004). The waste is constantly decreasing, and the value of the product manufacturing cycles constantly straying to make as cheap as possible to satisfy the consumers' needs is the critical factor in becoming competitive in today's industry without losing the customers and the confidence of them the lean concept is the one which helps to identify the waste and eliminate them (Rajnoka R, Dobrovič J. Galova K., 2018).

Lean methods include many principles, methods-specific tools, and operations that help identify activities that do not give an adding value to the process or strategies, as mentioned before. This thinking does develop new thinking and necessity of human resources to try adopting lean methods into gaining perfection of not only the flow but staying competitive in the industry, by forcing the competition and the cooperating companies to improve by adopting the methods to stay in the market competitive and relatable to work. (Zorana Tanasic,2019). The spreading of never-ending improvements and growth does affect the environment. The equalization process is made from the uneven diffusion of the companies in the industry, wants to improve and work more efficiently and positively affect the organizational performance. (Madsen and M.Storveen, 2016).

From the beginning of the lean concept emergence, the best performance resulted in the production forking companies. The lean methods could reasonably say it is the most potent strategy for the companies that do have the production and manufacturing lines, not depending on what industry they are working on, although as it is known lean principles were started to use in automobile manufacturing companies as mentioned in Toyota Production Systems. (Karlsson,1996).

The implementation of lean methods does begin from genuine commitment and strong leadership. The lean methods, after the implementation, if they are equipt properly, have a significant impact on many areas in the company and abroad (Ramon Fayek,2013). As was mentioned before, the lean methods after the implementation give a minimum waste and high value for the companies.

To add about the advantages of the implementation of the lean methods to the companies or the organizations' research was done about lean thinking (Paulo Amaro,2019). Continuing lean thinking and lean methods could help companies become improvements seeking company. Also, this helps companies become more creative and generate unique ideas to become more competitive in the industries. Also, the quick problem-solving ability is implemented with the help of lean methods not to let the manufacturing process or other processes stop the activities. Lean thinking helps companies

to pursue perfection in the everyday tasks; this mean reduces the waste: the manufacturing process waste (material, tools, machines, and etc.), environmental wastes with eco-friendly materials that could be recycled or reproduced, and also eliminating the unnecessary human potential (Paulo Amaro,2019). The lean methods have many different values and benefits of implementation that could be used for many different sectors of production or manufacturing.

With the motives, there are always barriers in the company's path on fluent implementation of lean methods. The barriers might be valued from the internal problems or the external factors and problems companies face (Mohd Marhani, 2013). The barriers that companies are most frequently facing to implement lean methods are: managerial (low leadership qualities), technical (the tools are of the company are weak), human attitude (negative employees look to changes), education (lack of knowledge), financial and lack of discipline

To sum up, lean methods are an integral part of companies. Lean helps companies estimate efficiency, achieve performance and guarantee the best quality for the customers. It helps develop a strong relationship between companies and helps to improve both sides of the cooperations. Lean concepts are no longer used only for automobile manufacturing; they can implement into the different manufacturing sectors that have nothing to do with cars or machine production. Lean production methods are more likely now used as a strategy than the concept (Jim Wu, 2002). These methods are the ones that help the companies grow and stay competitive in the specific market they are working in, helps them to achieve the goals of better productivity. The diffusion of lean methods might interact between companies because lean methods are the ones that add value when the company knows how to implement it correctly and is not influenced by the factors that could lead company not to innovate any more.

1.2. The analysis of diffusion of lean methods

Diffusion is an inseparable theory from innovation. After much research and analysis, James W. Dearing (2009) has concluded that diffusion is an essential process. The diffusion of the innovation, or in this case, the implementation of lean methods, really significantly impacts the companies that would try to implement lean methods in their organizations. Based on James (2009) the innovation or the adoption of new strategies might take some time for the starting companies, but the diffusion size might impact the companies that hear about the innovative solutions. As it was said, the diffusion is making the implementation time longer to the 100% adaptation.

It is already known that for the diffusion of the innovation or lean methods, this case has seven elements that impact the diffusion of it and could be characterized and explained (Elihu Katz,):

- Innovation acceptance – the acceptance of innovation is usually a dependant variable from the interest and situation. Acceptance is declared usually after the first usage of the innovation or classified in the research question.
- Time – the time for the diffusion is one of the essential elements because this signifier helps to understand how long the diffusion might take for the companies to adopt the specific innovations and could be evaluated as the sequence or similarity for the upcoming innovations to predict.

- Specific practices – the problem of the specific practice elements is that they are not always agreed upon unanimously. The classification of these items is challenging because it has conducted the point for the specific audience. The biggest problem is that not everyone is sure the elements are relevant and a low number of researches done it. It is shown that the ideologies even in the saim research fields give different elements of diffusion items.
- Adopting unit – another way how the items could be classified to determine the rates of the adoption. The unit of the adaptation might work not like the item or the requirements of the item, because as it was mentioned before, it is tough to intend the specific item for one purpose of diffusion. The adaptations of the innovations have an impact on many different variables.
- The specific channel of communication – is that the innovation transfers from one specific usage point of the innovation to another, but there are no specific classifications that might show how it is done. It was known in the past that information of the innovations was made through communication, but this day the channels have improved as the highways, social media, and the eagerness of the competition.
- Social system – the social system is usually constructed to identify the specific boundaries for the innovations and new ideas where they should diffuse and at what level. Another thing, the social structure does show the most prominent face-to-face communication channel through which the diffusion gains the most significant impact, to be more explicit, though this channel innovation diffusion is the strongest. A social system is responsible for conducting the specific ways of the diffusion to reach its points in the correct order – as was mentioned, the boundaries are conducted.
- The system gains value – this element shows that the specific policy or strategy gains value or a firm name of the independent or dependent culture from the specific factors. The main idea of this element is to determine whether the innovation or new ideas policy fits the specific culture of the groups or the cycles them. It is known that compatibility is usually a complex process, but this is why the values are defined, to know the truth are there it might fit the best.

There are many analyses and researches are done to understand the value of lean implementation andits effectiveness. The problem is that there is not much information about the diffusion of lean production methods across the countries, making companies use specific methods, including Lithuania. The popularity of lean methods continues to grow, but it was found (Dag Madsen,2019) that the popularity or diffusion of lean methods in the private and public sectors does show a significant difference. To understand the better concept and the what value and improvements are needed based on the diffusion of the lean method, this research will help to get a clear view of the diffusion in Lithuania manufacturing companies on what kind of factors do companies struggle to adopt more production methods, what is the natural separation of lean methods in Lithuania companies in different sectors of the industry.

The increasing competition in the industry between companies is forcing managers or leading heads of the organizations to find new methods or solutions, strategies to increase the value and lower the costs for the customers, perform better efficiency, and increase quality. It actively demonstrates that companies are trying to make a more efficient manufacturing flow, creating new customers also

involving old customers in a working chain by implying continues improvements by improving supply chain by improving with lean methods diffusion between the companies. (Martin Pech and Drahoš Vaneček, 2019.)

In 2018, research done between two countries Czech and Slovak republics by taking a survey of both country's manufacturing companies. (Rajnoka R, Dobrovič J. Galova K., 2018). The research idea was to understand and see if there are fundamental differences between the companies who use lean production methods in random specifications manufacturing companies. By doing this research, the survey would show the frequency of specific selected methods that companies use; the survey would reveal how the principles are diffused among the countries. However, this research only shows the frequency of users and not used lean methods but does not give any results on what factors affect these numbers. The research only summarized the existing diffusion in the countries. Thus, by leading to a result of efficiency and value the companies produce lean production usage. It shows that if the lean production methods or other principles are used vividly and adopted from the business partners, the workflow improves both companies and helps achieve better results just by sharing the knowledge with the cooperating companies.

From the research done of the Czech and Slovak Republics, it is clear to say that the Czech Republic is the one who uses most frequently most of the lean principles, this reality show in the numbers they achieve and the methods they use (Rajnoka R, Dobrovič J. Galova K., 2018). The result of the research study concludes that the Czech Republic could gain a significant competitive advantage over the Slovak Republic shortly taking the form of higher efficiency and productivity in manufacturing companies, the particular reasons for the circumstances of the method policies used. The analysis not only took the manufacturing companies but the producing companies. For the Slovak companies to grow and become more efficient implementing, some lean production methods to their process development and future improvements, innovations. The problem is that are not outlined the specific factors that might help to even up the diffusion of lean methods, the only factors that companies are interested in implementing the lean methods are increasing efficiency and realizing the actual profit for the organization (Thomas Janoski, 2019). To get the issue, Czech Republic companies do bring more attention and openness to the companies working by using more lean production methods and trying to adopt one from another. However, the real question is really to understand when countries are near each other, but the mentality is different, and the diffusion shows that the countries are located near to each other geographically, but the idea and the culture are separated and going in different directions.

Another research done on the Norway companies in the period 2015-2017 was made to show how lean methods are diffused among the different sectors of the companies (Dag Madsen,2019). After the long implementation process, lean methods and the policies have been adopted for the different sectors which is why lean diffusion must be challenging to use: lean production, lean healthcare, lean accounting, lean construction, lean manufacturing, lean management. Because of the separation of the sectors, the different lean methods are being used, and the diffusion becomes more significant of lean methods. After analyzing the frequency of lean methods that determined the number of employees, the use of lean methods and if the company adopted lean methods or if it is willing to adopt them (Dag Madsen,2019), this case showed that the popularity of lean methods is growing in Norway's companies.

Understanding the lean methods helps companies understand the value of the company's efficiency and reduce waste by implementing some principles. To help Indian manufacturing companies improve their efficiency, research was done giving most attention to the principles like Total Productive Management (TPM) and Total Quality Management (TQM). (Saumayranjan Sahoo, 2018). As this research is done, it would be available to foresee the methods that help companies stay competitive and what the companies based on their size, number of employees, the tools they have, and location. After analyzing the survey, it would be clear to understand what principles Lithuanian companies are using most frequently, where the most methods are concentrated, and why they are so diffused in the companies from different companies.

To determine companies to use lean methods and lower the diffusion of lean methods between them, the managers of the organizations must identify the values of the lean methods and not just the philosophy of the factors that might influence the innovation process (Leksic,2020). There are many arguments why companies are implementing lean methods: efficiency, better manufacturing flow, etc. However, the real problem to investigate the factors that impact the diffusion of lean methods. By doing that, the ideology of lean methods could spread to all the companies to show them what the value is gain from lean methods policies.

The problem of the research work is to identify the factors and constants which do impact the uneven diffusion of the lean production methods through the whole country and the companies athat are working in it. The research work will help analyze the problems of the better spreading and adoption of lean production methods based on companies facing Lithuania. It has known that the diffusion of lean methods is uneven because it has interfaces with the labor system and conducts the separation between the large companies and the micro-ones. The information analyzed in this research project will determine the companies, look more open to implementing lean production methods, and understand the value of them in the manufacturing companies, the advantages companies might get, and investigate the factors that could determine the complicated implementation process.

Size is the helping factor for companies to implement innovation because of its capability to control extensive processes in their everyday life routines. There is mentioned (Tortorella,2018) that lean thinking does help companies to achieve better efficiency, better results, better growth rate, and better quality for all type of size companies – micro, small, medium and large companies. The problem is that there is no significant evidence, which of the rate size does use lean methods more than others, how the methods are diffused in these size rates. The analysis with the conducted rate of size could reveal if the company's size does impact the diffusion of lean production methods in Lithuania.

The interest in the diffusion of lean production methods still stays lacking. There is not much information about the diffusion of lean production principles in countries companies or even Lithuania. This is done to understand how the principles are diffused and possibly what kind of factors could determine the diffusion of the lean production methods in companies in Lithuania in the production sectors. The diffusion of lean production methods is vital to know the particular reasons for the circumstances it would help the companies adopt the principles to improve everyday tasks by removing the issues that do interfere in the process path or even internal faults.

1. Lack of information about the diffusion of lean production through manufacturing companies.

2. Not concrete research have done what factors lead to uneven diffusion of lean production methods.
3. To identify the current situation of lean production methods in Lithuania companies

In conclusion, this research project aims to understand better how lean methods are diffused among the producing companies in the Lithuania industry, what methods are used more frequently, what value they bring. Because as it is known, there are no specific research done or analysis done to evaluate how the methods are distributed among companies and how they are diffused in the Lithuania industries. The factors that impact the diffusion of lean methods will be analyzed in the research to get a closer view of the diffusion of them in Lithuania and get a closer view of which factors could lead companies to adopt the lean methods which ones do not. By doing that, companies in Lithuania could identify the lean method diffusion and realize the value of the specific lean methods and the usage across the whole country. By reducing the uneven diffusion of lean methods, the companies could accelerate their true potential by looking from the perspectives on the specific factors.

2. THE THEORICAL ANALYSIS OF FACTORS INFLUENCING UNEVEN DIFFUSION OF LEAN METHODS

2.1 Model of uneven diffusion of Lean methods

The model was created based on research into lean manufacturing practices (Shah and Ward 2007). There were outlined the elements separated in the specific sectors as shown in the figure below (figure 1). Ten methods are structured in three specific groups: supplier-related (3), customer-related (1), and internally related (6). The numbers in parentheses show the amount of the elements belonging to mentioned groups.

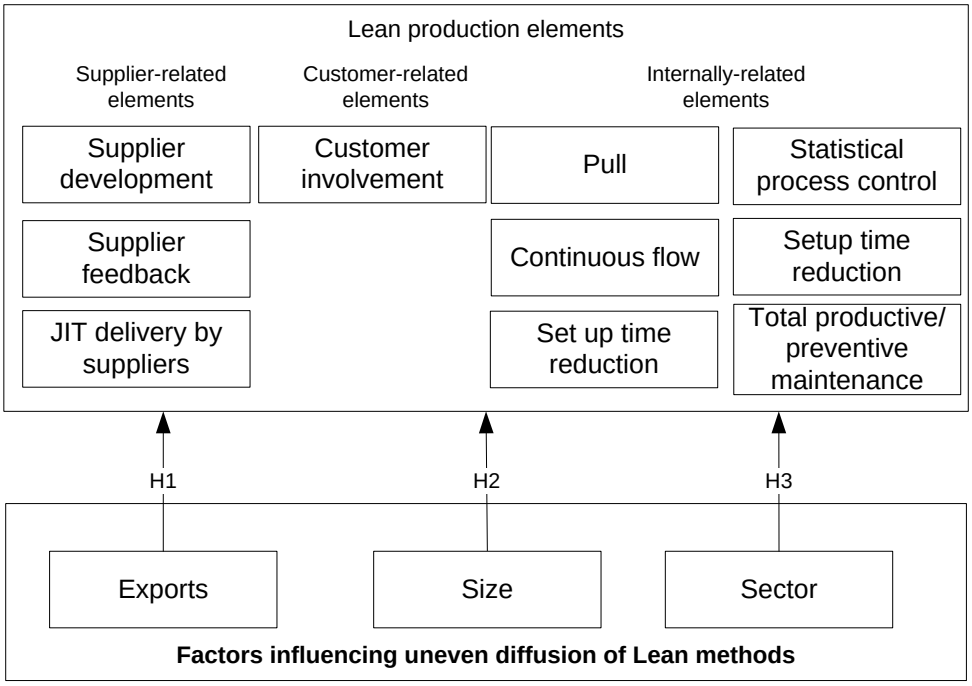

Figure 1 Model representing the factors of uneven diffusion of lean methods

These groups shown in the figure above (figure 1) are gathered and formed into the model that would be easier to get uneven lean methods diffusion in Lithuania. To get closer to understanding what factors do influence the diffusion of lean methods. With these groups, every method will be used to better the results' accuracy and get a better view of the actual situation in Lithuania production industry. Three hypotheses were madefrom theformed groups, to help the researchers better understand how the principles are diffused.

H1. The lean methods are more extensively adopted by exporting companies than not exporting companies.

H2. The higher the size of the organization, the higher the adoption of lean production methods.

H3. There are significant differences in the adoption of lean methods among companies belonging to sectors of production.

These hypotheses will be evaluated during the research project after getting the actual result; then, they will be approved or denied. It will help to understand and see how the methods diffused in Lithuania.

2.2. Lean production

After analyzing the research and scientific works that provide information about lean production methods that involve improving the company's parts and processes that help companies achieve better results in efficiency, quality and accuracy, there are three different constitutive elements. The first one is Internally related elements, second supplier-related elements, and customer–related elements. (Shah and Ward 2007).

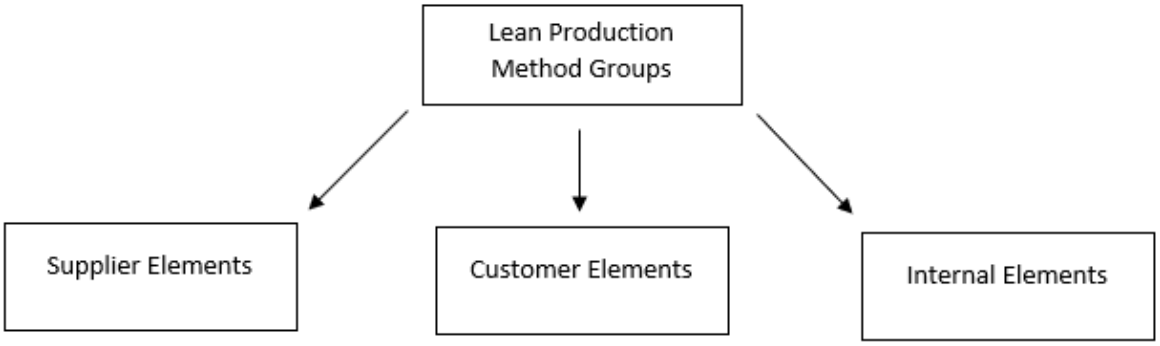

Figure 2 Lean production methods groups (Made based on Shah and Ward,2007)

Later in this research, it will be detailed what these method groups are shown in Figure 2 consist of specific lean production methods. The diffusion of the method that will be done in this research will help understand the actual value and meaning of diffusions between companies in Lithuania and the impact of diffusion on to the companies. What factors do stimulate the diffusion between the country and its companies, why it is hard to export their product due to ''leanness'', how companies fail to evaluate the benefit of lean production methods and why using these manufacturing principles are so uneven between the companies. These elements will be analyzed more broadly in this research paper, to better view the value these lean production method groups generate to the companies and the companies working with them – suppliers' companies and customers companies that work and buy services.

Generating perfection in the manufacturing process, companies try to improve the cycles of the manufacturing flow to reduce the value and waste in the process. Companies worldwide implement lean production methods to generate effects on the normal processes that the company does. (Saumayranjan Sahoo, 2017) The never-ending improvement is needed for the companies of Lithuania to grow and produce more jobs for people. To reduce manufacturing cost and try to achieve the more significant value for the customer to be satisfied. This could be done by following the main lean production principles that were found in the scientific researches.

With the help of the research done, as mentioned before lean was separated into three groups, which has ten methods shown in the figure above (figure 2) belonging to the three groups.

- Supplier - related elements
- Customer - related elements

- Internally - related elements

To sum up, there were outlines three lean production methods groups with different elements, that will be the guideline for this research and help evaluate the diffusion in the Lithuania companies.

2.1.1. Lean method groups

The lean method groups, as it was mentioned before, do consist of several specific methods that will be presented in this paragraph to understand and get to know closer the true meaning of them and the input they bring to the company's everyday processes. The analysis will begin from supplier-related methods.

Supplier-related methods group:

- Supplier development – Suppliers get involved in the company's development (e.g., Exchange of cost structure information)
- Supplier feedback – Getting feedback from the suppliers on the delivery problems and their quality or other issues.
- JIT delivery (Just-in-time) – direct delivery to the production process, not collecting and keeping in the company as a warehouse.

Customer-related methods group:

- Customer involvement – total customer involvement in the production process (e.g., joining product innovation and development)

Internally related methods group:

- Pull – Production controlling by using the Pull principle.
- Continuous flow – Measuring improvements of internal logistics in the company.
- Low setup – work with the processes to reduce the setup time.
- Statistical process control (SPC) – methods of statistical control, analysis.
- Productive maintenance – measures to address equipment downtime of machines
- Involved employees – Involvement of employees into the innovations in the company

These are the elements that are shown in an above of the lean production principles that are measurable to gain the value and the understand the problem of the uneven diffusion in Lithuania, how they are spread through different specifications of the company, and other factors that will be taken in a survey of this research project. These methods will help to identify the problem of this research that companies do lack the sense of the new methods to adopt.

2.1.2. Internally related methods

The internally related lean production methods are the ones that are focused mainly on the company's manufacturing flow, the primary view looking from the employee's perspective about the improvements, constant equipment improvement and getting most efficient features and also organizational factors. These approaches focus on maximizing the operation of machinery and

manufacturing flows, which provides stability to the manufacturing process and aids in understanding the importance of eliminating unnecessary waste from the process. (Shah and Ward 2007).

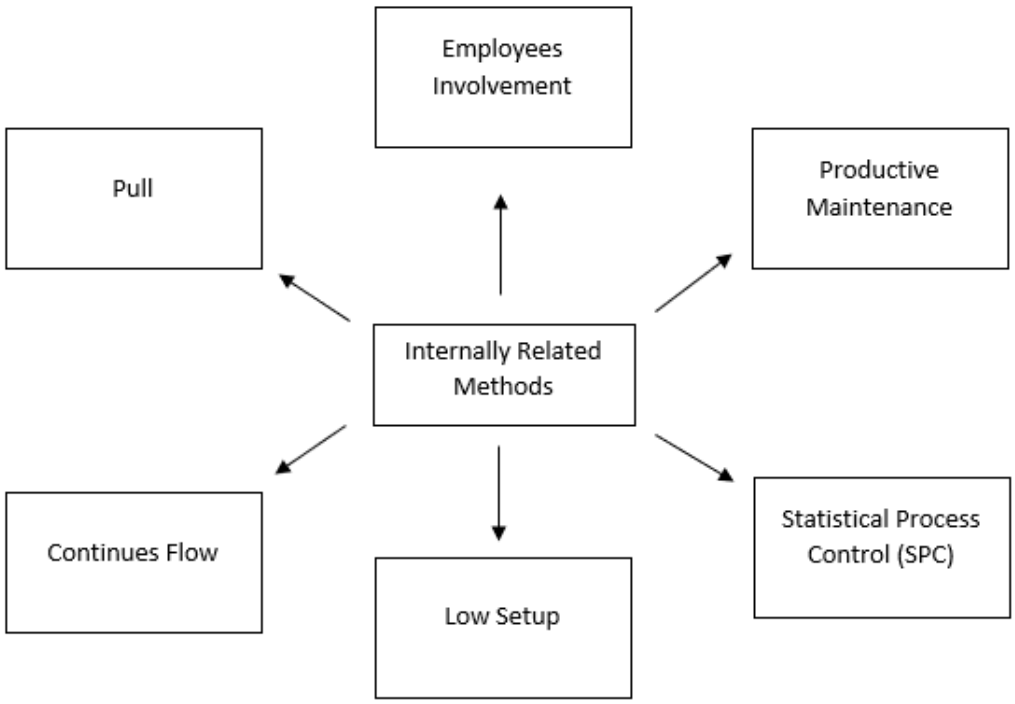

Figure 3 Principles belonging to internally related method group

Pull – This principle will help companies structure their manufacturing flow by preparing all stages with the specific tasks to be operated at the specific time and at the specific place, to increaseefficiency. In the United Kingdom, there was research done (Majed Alsmadi,2012) that indicated that almost 84% of the manufacturing companies use the ‘‘Pull’’ principle (0,8333). The production is pulled by all the current sectors demands to increase the efficiency (0.7654)

Continues flow – This principle is the one which would help the product to travel through all manufacturing places instead of giving work to different groups. This principle classifies products into specific groups with similar processing requirements (0.7654) and routing requirements (0.8111). The demand usually makes the pace of the customer’s manufacturing (0.8444); by doing that the customer will be satisfied with the service the company is providing.

Low setup –This principle creates a chain starting from decreasing the manufacturing time by leading to a lower labor cost and a faster delivery to the customer. In the research of UK manufacturing companies (Majed Alsmadi,2012), it was found that the employees are usually taught to reduce setup times (0.7865). The long production cycles will not allow responding to the customer request quickly (0.7992). Also, this applies to the supply chain. Thus, the setup time must permanently be reduced.

Statistical process control (SPC) – This method is the one that keeps an eye on statistical data through time and does the never-ending analysis on the processes that are done. The methods help to analyze how the processes might be improved to reduce manufacturing cycles. The analysis is mostly done before the launch of specific machines or other components (0.6633). There are usually made the

event the defect rated according to the research paper (Majed Alsmadi,2012) when the manufacturing pace is not good enough (0.8900).

Total Productive maintenance – This principle is used to address the actual value of the equipment and the value it has made to the company. This helps the companies to maintain the equipment regularly for specific periods (0.8765). It helps for all the machines and other contraptions up to date and would not interfere with faults during the manufacturing process (Majed Alsmadi,2012).

Involved employees – This method helps involve the employees to the plans, and the innovation company is facing, to keep them active and ready to learn. There is usually cross-functional training (Majed Alsmadi,2012) to make a higher qualification for the employees (0.8001). Also, the management is very open-minded and do listen to the employee's suggestions of the manufacturing cycles, the reasons for the circumstances they do know how to improve them more from everyday experience (0,5988)

From the research and analysis done (Majed Alsmadi,2012) that indicates the internally related methods every principle has a significant impact on its infrastructure and ability to improve the everyday task. The factors on improvements show that above 50% of companies see significant results of implementing lean production methods into the plants' manufacturing cycles. These methods will be used in the research work, survey to identify some accurate result on how lean production methods are diffused around Lithuania's manufacturing companies.

2.1.3. Customer related methods

The customer-related lean production methods are the ones that stimulated the sharing of lean production principles with the customer to help him improve his processes and, by doing that - improve the company's flow. This involvement helps to understand the customers' needs and helps develop new improvements to the products to help continue the never-ending improvement cycle, talking from the perspective of the design, sales, customer service, etc. (Carla Beatris, 2019). The created value is usually understood a pack of deliverables covering the customers' most needed interests (Osterwalder et al.,2014). It is known that actual value is represented by the benefit that is directly given by the company which brings the product or the service to the customer, that satisfies all of these needs (Yrjola et al., 2017)

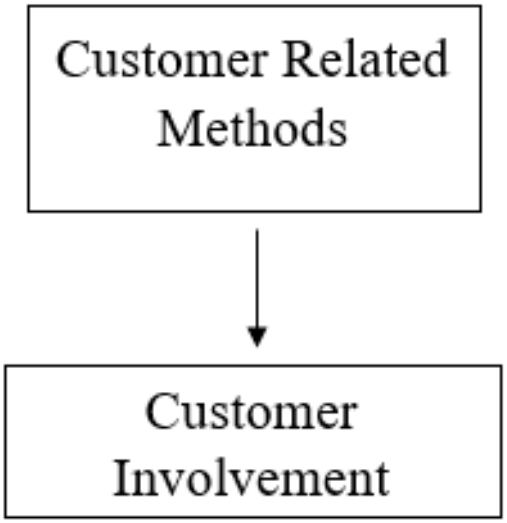

Figure 4 Principles belonging to customer related method group

Customer involvement – This principle is used to give the customers a better view of the processes company is doing to help them come closer and start to give advice or improvements to the companies there are using the service or buying products or their businesses. This method helps companies to change ideas and cooperate to get a better result on collaboration. Based on the researche that was done, several factors influence the workflow based on customer involvement. As mentioned before, customers are directly involved in the current and seeking future product offerings, help increase the company's revenue (0.8342). It was outlined that customers do come more frequently to visit the company plants to see how the projects are being manufactured and how the whole process will impact on a better relationship (0.7865). The particular reasons for the chain reaction's circumstances start, and the customer always informs the companies about the product quality they are receiving and the delivery experience. The customers always share the future demand information with marketing departments (0.7321). These are just the several factors that do show a positive impact on the companies if they are trying to involve the customers. The examples were taken from the research done on lean methods (Majed Alsmadi,2012)

From the analysis result done in 2012 (Majed Alsmadi) it is clear that customer-related methods do impact continued improvements in the companies' everyday life. The factors indicate more than half of the factor's evaluability, which means that these factors do bring value to the companies and the customers they are working with. This method will also be used in the research work to get some accurate results on how lean production methods are diffused around Lithuania's manufacturing companies.

2.1.4. Supplier related methods

These suppliers related lean production methods help improve the delivery time and the quality of the supplier products. Manufacturing and technology methods are essential in the value creation cycles. The supplier-related methods are the most helpful way of trying to eliminate the unevenness of production method diffusion, because of the companies' working flow with many companies and

gaining principles to improve the service flows. The build buyer and seller(supplier) relationships and working together really bring out the value of developing a long-term relationship, preparing the best quality products and services, helping each other save on resources, and giving the partners' priority case (Ansari and Modarres, 1988). It is proven that the implementation of lean manufacturing can lean to more than 50 percent of less human effort needed, less manufacturing space, tools investments and the manufacturing time of the final product, thus leading to a better quality of the product (Zayko, 1996). According to Helper (1991), the plants need to make an efficient and close relationship with the suppliers and develop the JIT delivery method. That would lead to better customer satisfaction with the quality and start making the most competitive companies in the market. After the research is done (Yen Chur Wu, 2003), it was outlined that:

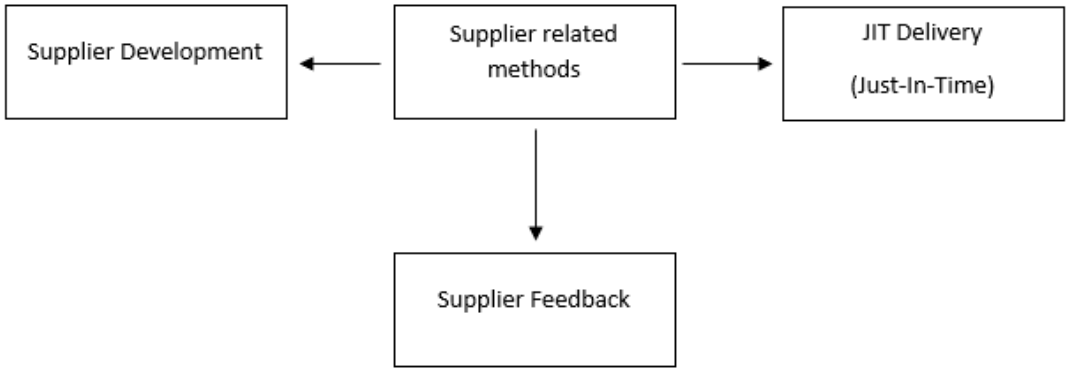

Figure 5 Principles belonging to supplier related method group

Supplier development – This principle provides the strategy that would help identify the value supplier brings to the company and how the value could be grown. The growth would impact the customer-related methods also. As it was done on the research (Majed Alsmadi,2012), the measurements were made what kind of impact factors of supplier development gives to the companies. The supplier is annually committed to reducing the cost of the materials or the services it is producing (0.8274). Usually, when companies agree to make supplier development, it is mainly located nearest the companies working with (0.8112). The biggest suppliers usually manage the company's stocks, and inventory keeps track that everything would be at the right level (0.6874). To pick the best supplier, companies usually depend on the quality and not on the price per unit of the products, the price a whole (0.5798).

Supplier feedback – This principle is used to empower excellent communication between the supplier and the customer. This will help to improve the processes that are done in the correlation process. The reserach done (Majed Alsmadi,2012) shows the most influenceable factors on companies based on supplier feedback. The most significant impact was that suppliers frequently visit the company they are supplying (0.7125), and the company visits the supplier's plants (0.7456). The most crutial factor is that the companies will try to make a long-term relationship with the suppliers to get insurance that the materials or the products will be delivered (0.7981). These are the factors that usually take place by taking the lean methods.

JIT delivery (Just-in-time) – This principle is used, that the material or the service, products would arrive at the company with the spiffily identified parameters and time, that there would be any waste and the material or products would lay on the companies ground to wait its turn for the manufacturing

process as like in the warehouse. For the Just-in-time method in the research (Majed Alsmadi,2012), it was mentioned that this method helps the suppliers to get directly involved in the new projects and products development processes to start looking for the issues and the best ways to generate the competitive price for the customer's needs (0.8186). The company and the supplier have made an agreement that the material and other products will be delivered on a regular basis; this action demonstrates that at the right time and with no delays, this helps to stay competitive in the market and the efficiency is higher, besides there are no stocking of the material or products in the plant area (0.7564). After the research is done (Yen Chur Wu, 2003), it was outlined that JIT delivery did not just reduce inventory-carrying costs, but the plants do spend less on emergency shipping, and no more on standard shipping's, companies that use JIT delivery will spend less in inventory stacking and delivery costs.

Supplier-related lean principles are a considerable and vital aspect in the growth of the company's efficiency and satisfaction. From the research mentioned before, it is clear that there is a significant impact on the plants manufacturing speed depending on the supplier and cost perspective. These methods will be investigated in the survey that will be taken to get a better view of how the lean production methods do diffuse around Lithuania's manufacturing companies and what impact do these methods give due to the diffusion.

2.2. Lean production factors are related

This research will use 10 lean production factors that will help identify the uneven diffusion of lean methods in the companies of Lithuania. These ten factors are after the analysis done do show the correlation positively with each other with the value ($p<0.001$) supporting the multidimensional and interconnected design of lean manufacturing systems. Figure 6 (Shan and Ward,2007)

	Latent Variable	# of items	1	2	3	4	5	6	7	8	9	10
1	SUPPFEED	3	0.77 (.53)	32.4	38.3	64.6	34.7	21.6	29.4	38.4	14.8	56.8
2	SUPPJIT	3	0.53	0.66 (.39)	48.7	69.1	14.6	27.2	33.5	41.0	30.8	52.6
3	SUPPDEVT	6	0.65	0.76	0.74 (.33)	61.8	41.8	43.5	29.8	31.8	29.8	57.5
4	CUSTINV	5	0.29	0.22	0.43	0.85 (.55)	53.6	62.3	44.6	46.3	66.3	66.6
5	PULL	4	0.26	0.56	0.38	0.22	0.88 (.66)	9.5	25.2	41.4	27.8	29.6
6	FLOW	4	0.36	0.43	0.35	0.15	0.49	0.75 (.45)	15.5	32.2	18.8	30.4
7	SETUP	3	0.38	0.46	0.52	0.36	0.48	0.55	0.75 (.51)	11.2	8.4	44.5
8	SPC	5	0.42	0.45	0.66	0.44	0.31	0.37	0.61	0.86 (.60)	16.1	49.1
9	EMPINV	4	0.48	0.49	0.59	0.28	0.42	0.42	0.64	0.62	0.83 (.50)	46.0
10	TPM	4	0.19	0.30	0.26	0.12	0.31	0.27	0.19	0.25	0.17	0.77 (.45)

Figure 6 Correlations, reliability and discriminant on the study done (Shah and Ward,2007)

The high connection between the factors does open the correlation meaning. The concept of lean production is made from many inter-related elements that do have relationships between themselves. The primary idea of lean manufacturing companies is to reduce as much as possible waste by decreasing the supply, production time, and associated with uncertainty. They were minimized the inequality related to only source at the specific time to reduce only some of the waste from their

system and know that not all waste can be handled unless the business can simultaneously attend to each form of variability. However, reducing the preparation time variability alone does not eradicate excess inventory from the scheme, as the company may continue to retain excess inventory to satisfy suppliers' distribution variability. In addition to creating a reliable method, companies would have to secure reliable suppliers to minimize excess inventory of all kinds.

The ten underlying methods of lean production factors proposed here jointly enable companies to address not clear as follows. Material and all the products were put together in specific element groups to promote continuoses flow (Flow), and equipment is laid accordingly to the situation and equipment undergoes frequent and routine preventive maintenance (TPM) to avoid frequent stop-and-go operations. Closely grouped machines and product similarities allow workers to identify problems while cross-trained, self-directed employee teams can solve problems faster and more efficiently (EMPINV). Actively active clients (CUSTINV) allow businesses to predict consumer demand sccurately. Reduced setup times (SETUP) and tighter quality assurance (SPC) allow companies to more accurately predict process performance. Firms use Kanban and pull production systems (PULL) to manufacture the type of units required, at the time needed, and in the quantities needed, requiring suppliers to deliver adequate quantities of the right quality product at the right time. This JIT Supplier Distribution (SUPPJIT) is intended to provide suppliers with daily quality and delivery reviews (SUPPFEED) and to provide training and growth for further progress (SUPPDEVT). The supplier base must be limited to a few leading suppliers with which companies may have long-term partnerships rather than short-term contracts because no organization has unlimited money to invest. (Shan and Ward,2007)

The ten distinct yet highly interrelated elements are complementary and synergistic effects that give output its unique character and dominance to achieve multiple performance goals. While each factor alone is connected to better efficiency, businesses that can execute the complete set produce outstanding performance results that can lead to sustainable competitive advantage. The durability of the gain stems from the challenge of simultaneously implementing many elements of lean. The particular reasons for the circumstances it is difficult to accomplish the simultaneous implementation of so many elements, are also difficult to imitate (Shan and Ward,2007).

2.3. Factors influencing the uneven adoption of lean methods

The main key factor of this research project is to compare the lean production methods between the Lithuania manufacturing companies and identify the diffusion of the principles in the country's manufacturing companies. To investigate the unequal spread of lean manufacturing practices, some hypotheses are made and why these hypotheses were made. These hypotheses will be helpful for the understanding of how the methods are distributed in Lithuanian. The hypotheses were formed from the model made from the theoretical analysis (Shan and Ward,2007). The formulation of why these hypotheses were made is described in the next chapter to understand why they are made and the aim of these hypotheses.

H1. The lean methods are more extensively adopted by exporting companies than not exporting companies.

H2. The higher the size of the organization, the higher the adoption of lean production methods.

H3. There are significant differences in the adoption of lean methods among companies belonging to sectors of production.

These hypotheses will be evaluated during the research project after getting the actual result; then, they will be approved or denied. The research result could come to both ways because the theoretical situation might not reflect the current situation in Lithuania's production industry and its usage of lean methods. After the results are evaluated, it will be easier to answer what does stimulate the diffusion of lean production methods.

2.3.1. The lean methods are more extensively adopted by exporting companies than not exporting companies.

Export is always known to be one of the powerhouses for the companies that work in some production industry. Export generates the competitive companies to perform best results and be the leaders in the industry (C.L.Freund 2008).

It is already known to this day that marketing activity is used to investigate the local environments and competition also to developments of new capabilities and practices of adaptation (Dickson,1992). To be specific, the organizational literature usually explains how the internal policy of learning is a vital factor indeveloping adaptation policy (Lord & Ranft, 2000). The organizational theory constitutes that the companies will start learning when the strategy becomes closer to the environment and its innovations. The process of export is holding the early process of internalization, and it is known that the companies who develop and use exporting policies in their companies are more likely to use low-risk giving type of learnings (Özsomer & Gencturk,2003). The exporting type companies are usually more likely to adapt to the local and abroad markets by implementing their working mechanisms and trying to achieve the needed efficiency to work with companies they want (cf. March 1991). According to the research done (D. Greenaway, 2004), the export companies are most willing to know about these specific factors of the company or its products:

- Price of the service or the products
- Specific companies' production cost
- The delivery cost and terms in the foreign markets
- To know countries policy about exporting facilities
- Companies' plans and policies on continous improvements.

From the factors mentioned above, it was not challenging to develop the hypothesis exporting companies are willing to adopt lean production principles more openly than non-exporting companies. Companies seeking to export their product or services are likely to adapt to the companies trying to work with policies, thus leading to learning new strategies, new policies, and better efficiency that the companies probably would be looking for. This is why Lithuanian companies that might work with Western European countries may adopt the lean concept much more quickly simply

by driving the goal of working with companies that offer orders and have opportunities to expand the development.

By adjusting companies' policies and promoting the export means that the companies are responding to the innovation and the factors influencing the work internally and externally and forces companies to respond to export companies demands by improving companies manufacturing flow thus by decreasing the cost due to the efficiency and better quality with a better production time (Cavusgil & Zou, 1994). This is the theoretical argument that companies who export their product or services a lead to innovation and improvements policies to improve their production cost, delivery time, quality of the products, and continuous growth. The companies which exports are willing to improve this by adding lean principles from the companies they are exporting to will try to become equal to them in efficiency and also by doing that companies could spread the innovations and principles in the local market that the companies are working with to improve the companies around it to improve itself (Shoham, 1999).

Companies that prefer can export their products or services to abroad countries are the ones that can narrow the knowledge and technological gap between those countries by learning from each other (Robert Salomon, 2010). With the help of many types of research, it is known already that companies that are exporting tend to be more productive in the adaptation than the non-exporting companies (Delgado,2002). This is related to lean methods because the specific methods are knowledge that is also needed to be learned and adopted to its working cycles. The export help companies not just learn but to get closer to innovative thinking and continues improvements and investments in the companies (Penner-Hahn,2005).

From all the collected statements and the analysis done in the theoretical part, it is customary to say that the exporting companies are willing to adopt lean principles more than the non-exporting companies. This is said that companies which export are adapting more, but it will be seen in the results of Lithuania companies.

2.3.2. The higher the size of organization, the higher in the adoption of lean methods.

Lithuania as a country is growing and improving, this does mean that the companies of the country are growing also. Companies are growing, which mean the technologies are getting more innovative and the number of employees grows, the demands from the customers increases. Companies with high manufacturing power usually want to increase the competence of the employees, a better and more organized work flow and the efficiency of the processes are completed in much more optimized time and also to generate a better power of manufacturing or producing services.

There are not a lot of researches done about the companies, who tend to have a large number of employees and to gather many investors and perform big revenues and efficiency results. There are several comparisons that is the ‘‘size’’ means. Some evaluate as the all the machines and contraptions that belong to the company and this is how it is evaluated if it is a big company or not. The other define the size based on the emplyoees size and the amount of work it can generate. It was shown (Wahidahwati, 2002) that the big companies usually spend more money in the internal usage. This actively demonstrates that that big companies are willing to spend more on the improvements of the cycles to become more competitive in the industry. The researches were done and shown that companies big companies are usually generates a greater effect on companies' value, this includes, investments in manufacturing flows, employees' higher qualifications, better relationships with

suppliers, making efficient working schemes. Companies with a bigger size rate has a bigger chance to enter the market capital that does require investments. Because bigger size companies are usually having a policy to invest internally to improve its manufacturing flows, it is being seen by the investors based of the company's clear future plans and after these operations the company's value increases. The size of the company usually shows weather it is having a good growth or not in the innovations and cycles improvements. (L. Stevanus, 2017). This already mentioned, that large volumes of sales are made by fixed cost which are basically made over large sale base. To be more concrete, large firms have a bigger range of knowledge and human capital skills also than small firms, allowing the bigger companies to improve its rates of innovation (M.Rogers, 2002).

To simplify all the collected information, the bigger companies have a broader view with the companies they are working and collecting new knowledge from them. It is shown that larger companies are tending more to grow and to improve their efficiency to stay competitive in the industry and continue on improving its cycles to generate better results to grow even bigger. There are many factors that influence the companies to grow, but the grow means leading to a new adaptation of new technologies and principles that would help the companies to achieve better results in the yearly stands. This is very important to understand that large companies have investors, who also put pressure on the companies to get better results, this is why form the theorical findings is clear, that larger companies tend to improve more then smaller ones. ''For large firms innovation tends to financed safely, while small firms' innovation ussally lead to the quation of debt'' (Dijk et al. 1997). The small companies usually have not a lower financial risk to innovate and try to improve which might lead to fast and direct improvements, while the large companies can't be this efficient in the innovation integration process, because the bigger the companies the more specific places and processes must be innovated, this is why larger companies focus more on internal knowledge innovation (S.Gopalakrishnan, 2006). It is known, that committing a fast innovation and improvements without building a strong internal knowledge could lead not to the improvements, but to total deviation from the specific goals and end up with no adding value to the companies (Levinthal & March, 1981).

All in all, the larger companies are the ones that have a bigger expand of material and recources. These companies usually make their activity for a long period of time this is why they build strong relationships (Crakrabarti, 1996), which might be helpful for the companies to adopt the lean methods to their companies every day flows, because these methods are also the process of innovation and adaptation of improvements.

2.3.3. There are significant differences of adoption of lean methods among companies belonging to sectors of production.

As it is already known, the concept of lean was firstly mentioned in the auto manufacturing fields as a policy to improve the daily manufacturing processed and improve its efficiency. This concept was made to let people get closer to understanding the production, break some myth of it, and talk more about its productivity (Krafcvik,1988). Lean production in evolving but there is a basic outline that could be used in many sectors, not only automobiles manufacturing where it all started and formed (Womack et al. 1991), but other sectors of production might use these simple factors that were outlined in the research (Christoper M.,1992):

- The value must be identified and delivered to the customer: everything that does not add any value, must be eliminated.
- The production has to be organized in a continuous flow
- The product or service has to reach its best quality and flow, pull and decision-making principles should be added to the inventory.
- The perfection: everything from manufacturing to the delivery of the product to the customer has to seek to make the best performance.

The lean principles were invented and used in the production sectors. Although the research dis that which sectors usually adopt more lean principles than others there are not many. The research is done (G.Torrorella, 2019) on the manufacturing companies did the age of the experience variables and the frequencies of the principles to understand the usage of lean principles in production sectors. Also, there are sectors as health care and public sectors growing in using lean methods just as production sectors do. However, to this day, the production sectors are divided into several sectors like food, basic steel production, furniture, etc. This might show what factors are tending to adopt lean principles than others more. The particular reasons for the circumstances some sectors based on age are newer to the Lithuania marker than the others. This might be one of the differences that sectors might not be very similar in adopting lean.

It is already mentioned that many articles (P.Burcher, 2006) do show that lean production methods implemented into the companies do stimulate to become more competitive in the industry and keep the competitive pace in a small thing like a better workflow of the accuracy of deliveries. The diffusion could be separated depending on the specific sector count of working companies. The higher the number of companies working in the same sector led to a more considerable competition; thus, the lean method is the one which might help companies to improve their competition rate. It is already known that companies are trying to escape the competition effect to avoid the competition that would allow companies to continue in the innovations(P.Gustavsson,2011).

The organization sector will be analyzed and valued to get any results and any interfaces with any of lean methods to determine whether the lean methods are diffused uneven based on the made competition rate in the industry, what impact it has. To know which lean methods are more used in different sectors and the actual usage of them.

3. METHODOLOGICAL SOLUTIONS ON LEAN METHODS DIFFUSION

3.1. Research Methodology

The study of literature and the survey were used to achieve the thesis goals formulated. The study of the literature was used to expose the local and global dissemination of lean production techniques by comparing the dependent variables that would impact the independent variables. In order to reveal the diffusion of lean production methods in Lithuania, the survey that was used is necessary for the secondary analysis. The survey was a compilation of European manufacturing companies collecting data in Lithuania in 2018 (M. Vilkas et al., 2019) in this thesis to achieve the objectives made by the help of the conceptual model (Figure 1) and give the results based on the research problem.

Objectives of the empirical part:

To understand how it will be done, firstly the empirical objectives are determined in these steps.

1. Identify lean production methods diffusion in Lithuania (use Currently used)
2. Identify lean production methods‘ potential usage. (use Extent of used potential)
3. Identify the prevalence of lean production approaches in the assessment of lean exporting and non – exporting companies.
4. Identify how lean production methods are diffused evaluating different companies’ sizes 1-9;10-49; 50-249 and so on.
5. Identify how lean production methods are diffused evaluating different companies’ sectors.

These empirical objectives will help to provide the statistical secondary analysis of the collected data. The conceptual model from the theoretical part will help understand the factors that would impact on the uneven diffusion of lean methods. These objectives are chosen to develop and justify or deny the hypothesis raised about the factors that influence the uneven diffusion between manufacturing companies in Lithuania. The objectives were raised by relying on the collected theoretical information.

3.2. Questionaire design

The measurement will be created from the ten lean production methods discussed already in the theoretical analyzing part. It is usually natural that the research projects represent the lean implementation, barriers, motives in the lean research fields. The lean production methods diffusion in the field, as mentioned before, not a very popular topic. These methods are going be evaluated established on the survey results to identify the uneven diffusion of lean production methods between the companies in Lithuania, the factors that stimulate the spreading. The measurement will be used by the research done (Shah and Ward, 2007).

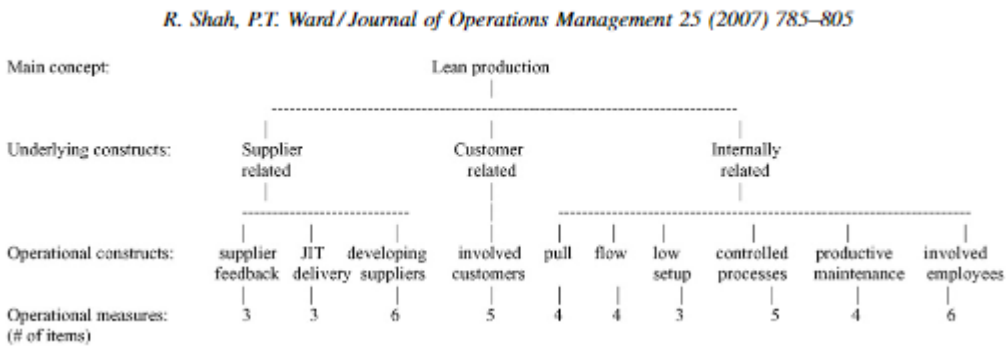

Figure 7 Conceptual and empirical mapping (Shah and Ward ,2007)

It needs to distill the measurement items into ten factors using a multi-step build creation process, which also maps the conceptual meaning. Figure 7 summarizes the mapping. Three of the ten variables listed in this study to measure the significant supplier engagement, one to measure customer participation, and the other seven discuss the company's internal problems. Together, these ten elements reflect the organizational counterpart to the lean development philosophy and define a lean system's ten distinct dimensions. (Shan and Ward,2007). These of the diffusion between Lithuania companies that have implemented some lean production methods to the cycles based on the factors that stimulated the adoption. From this measurement will be possible to identify the settled objectives for this thesis. Lean methods will be evaluated through the company;s size, sector the company is working, and the companies according to the factor if they are promoting export in their company.

Table 1. Measurement items of ten lean production factors

Group of methods	Lean elements	Questionaire items
Internally-related	Flow	Standardized and detailed work instructions (e.g. standard operation procedures SOP, MOST)
		Measures to improve internal logistics (e.g. Value Stream Mapping/Design, changed spatial arrangements of production steps)
		Customer- or product-oriented lines/cells in the factory (instead of task-/operation-structured shop floors)
		Detailed regulations on the arrangement and setting of the work equipment and storage of intermediary products (e.g. Method of 5S)
		Display boards in production to illustrate work processes and work status (e.g. Visual Management)
	Pull (pull)	Production controlling following the Pull principle (e.g. KANBAN, Internal zero-buffer principle)
	Setup (set up time reduction)	Fixed process flows to reduce setup time or optimize change-over time (e.g. SMED, QCO)
	TPM (total productive/preventive maintenance)	Measures to address equipment downtime of machines (e.g. Preventive maintenance or Total Productive Maintenance)
	SPC (statistical process control)	Methods of statistical control of production and quality (e.g. SPC, process capability analysis)

	Involvement of employees	Involvement of employees into improvement (e.g., A3, KAIZEN, PDCA, etc.)
		Integration of tasks (planning, operating or controlling functions with the machine operator)
Customer-related	Customer involvement	Involvement of customers into production (e.g., sharing demand information, joint product development)
Supplier-related	Supplier development	Development of suppliers (e.g., inventory managed by suppliers, exchange of cost structure information)
	Supplier feedback	Collecting supplier feedback (e.g., sharing information on quality and delivery problems)
	JIT delivery	(Just-in-time delivery (frequent delivery directly to production, not to warehouse)
Exports	Export	Estimate where your factory received its inputs from 2017 and where it sold its products
Size	Company size	Number of employees (e.g., up to 10 employees, 10-49, 50-249 or +250 employees)
Sector	Production sectors	Indicate your industry and the main (line of) product(s) produced at your factury (e.g., food, extiles, metal engineering industries)

A measurement item was made to help do a research thesis about the lean production methods to identify the diffusion in the companies based on organized variables exclude the most important factors that impact on the diffusion of lean methods.

Each lean method is included into different lean methods and will be evaluated different reserach conditions and will be evaluated to foresee the difference in comparing all lean methods in different situations. The situations will be the last three rows: export, size, sector. This done because from the theoretical part, these three factors were included as the ones that could give impact to the diffusion of lean production methods.

This measurement tool is made to make correct comparing and analysis for the lean methods in the proper sequel and keep the continuity. After the analysis it will clearer if lean methods are diffused based on the included factors mentioned in the theoretical part of independent and have no significant connection between them.

3.3. Sampling and data colection procedures

A telephone survey was used to collect the information. The method of stratified random sampling was used during the data collection. The questionnaire data ware collected in 2018 as a part of a manufacturing survey of European companies. The questioner is made in the English language, which was standardized and developed by an international research institution – EMS.

Strata have been specified in terms of four regions of the country and four organizational categories of scale. It was contacted with 2330 manufacturing sites. The overall sample size was 500 manufacturing sites, which represents a response rate of 21,45% of all manufacturing sites contacted. The response rate is over 20 percent which is required for the survey research. For all firm sizes, regions of the country, and coverage of all manufacturing subsectors, the sample has sufficient representation.

This data was used to achieve the set objectives and to analyze them to acquire a specific result that would reveal the actual diffusion of lean production methods in Lithuania manufacturing companies, help to identify the factors that do give impact to lean methods diffusion.

3.4. Statistical methods used

Empirical methods and questionnaire were used to carry out this secondary analysis study and reveal the findings based on the issue. For a start, the research begins with the demographical analysis, to get a better understanding of what type of companies participated (seven most significant sectors) in this survey, know their region, which was indicated by separating Lithuania geographically into four groups, to get a better view of the size of the companies which were included in four dimensions and the respondent position. In the second step, using the SPSS program, ana analysis was done to identify the currently used rate of the companies based on the specific lean method. The answers were evaluated into options (companies that did not answer were not included in the results):

- Yes - the company is currently using the specific lean method
- No- the company is not currently using the specific lean method at the moment.

The results of currently used lean methods are correlated into the final board, which was made out of all lean methods results to determine which lean production methods are used more frequently and to know which ones are used less in the percentage values.

From the perspective of the extent of used potential towards lean methods, the ten lean methods evaluated as the currently used lean methods. The difference is that the extent of used potential lean methods had three specific groups. The groups determined how much value does these principles bring to the companies and does it show a difference of currently used methods and the actual value they bring from the companies:

- Low – not much effect has happened after the implementation of the methods
- Medium – the company is satisfied with the principles with the added value
- High – company is delighted with the impact of lean production methods and made a big difference in the manufacturing process.

The companies that did not respond or were not using the principles were not evaluated in the analysis. The value low was indicated with the number 1, medium 2, and high rate 3 that were multiplied with gotten responses. This will help make an average value of all lean methods and see the real results on how the value is diffused. These rates were used to count the preliminary results in the formula to get the average usage of lean principles:

$$L1 = \frac{a \times 1 + b \times 2 + c \times 3}{\mathrm{a} + \mathrm{b} + \mathrm{c}} = L1avg$$

L1 – Lean method

a – Low-rate response count

b – Medium-rate response count

c – High-rate responsee count

L1avg – the result what is the extent of used potential on the specific lean method.

After the analysis, the results will be gathered in one table to see how the changes of lean value bringing to the companies and also to see the difference between them.

The third objective was made to analyze whether the lean methods are more diffused based on the exporting companies or non-exporting companies. In comparing the analysis method (John G. 2008), it is important to separate the variables into different variable groups that do have something similar in them (Pukėnas,2009). This is why the Exporting companies that use the specific lean principle and the non-exporting companies that use the same principle analysis were done to compare and see the true difference of lean methods in these companies. The same analysis was done for the size factor and the companies industry sector. The result could show the diffusion of lean methods. This separation will help see if the lean methods have any similarities with the evolved factors.

The Pearson Chi-square test was used on the lean methods to see whether they are dependent on the exporting or non-exporting company's factor. The results of lean methods that companies used and if comapnies are making export activities were analyzed and see if their asymptotic significance has a great value to confirm the hypothesis that lean methods diffusion is dependent on export.

- If the P-value (asymptotic significance) value is lower than 0,05, this means the variables are dependent on each other
- If the P-value (asymptotic significance) value is equal to or higher than 0,05, this means the variables are independent of each other and gives no significant impact

The next test was done as the Kruskal Wallis test, this test was also used to determine whether the categories that were used: size and sector, have similarities with each other. This will help identify if these factors impact uneven lean methods diffusion in Lithuania companies. The Kruskal Wallis test is used because the factors included different variables like:

Size: Micro, small medium and large

Sector: engineering, chemicals, wood and paper, textiles, food and other industry sectors.

After the test analysis is done it will be apparent if the lean production methods depend on the factors used in this research. The values that are over the 0,05 rate are signified as those, that have no depending impact from one another.

4. RESEARCH FINDINGS

4.1. Demographical analysis of sample of manufacturing industry in Lithuania

This research aims to analyze the diffusion of lean production and see the impact of its spreading through Lithuanian companies. To get a better understanding of this research, this will start with demographical analysis, which will consist of:

- From what region was data collected?
- Who were the respondents of the companies that the data was collected?
- What field of manufacturing do respondents participate in this survey?
- How many employees are working in the company?

Table 2. Sample the reserach characteristics

The characteristics of demographical analysis	N=500	
Industry	Number	%
Engineering	125	25.0
Food	64	12.8
Textiles	70	14.0
Wood and paper	156	31.2
Chemicals and chemistry	11	2.2
Other	74	14.8
Number of employees	Number	%
Up to 10	198	39.7
10-49	208	41.7
50-249	79	15.8
> 250	14	2.8
Respondent position	Number	%
Head/ director	333	66.7
Technical manager; Technical director of production	162	32.5
Branch head	4	0.8
Region	Number	%
South (Kaunas county, Alytus county, Marijampolė county)	157	31.5
West (Telšiai county, Klaipėda county, Tauragė county)	96	19.2
North (Šiauliai county, Panėvežys county)	82	16.4
East (Utena county, Vilnius county)	164	32.9

The demographical analysis was done with the help of SPSS and the Exel programs. There were 499 respondents from the all-different regions of Lithuania. This is done to get a better view of how the companies are distributed around the country's political territory. Firstly, the geographical location of the respondents was analyzed to know from what region do companies come:

- East (Utena, Vilnius)
- South (Kaunas, Alytus, Marijampolė)
- North (Šiauliai, Panevežys)
- West (Telšiai, Klaipėda, Tauragė).

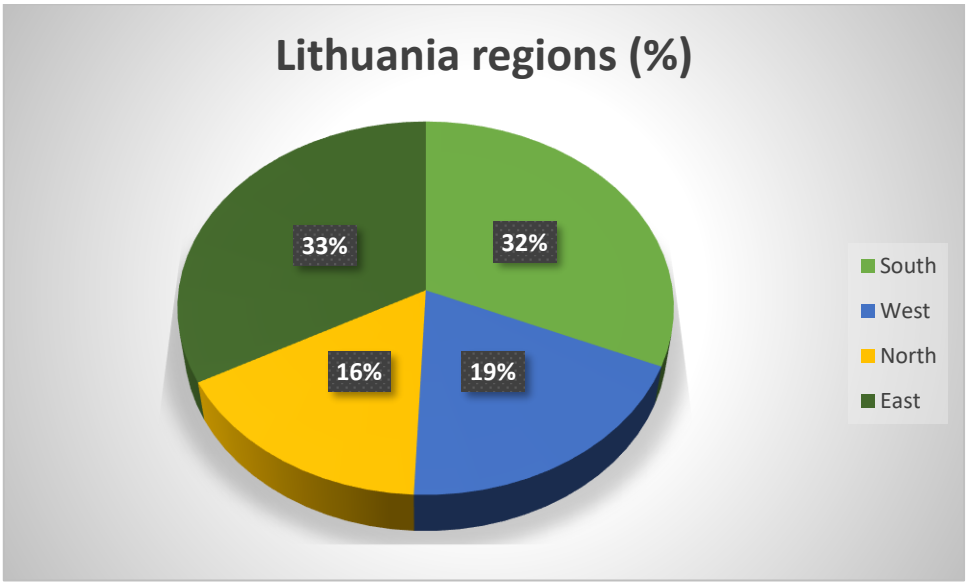

Figure 8 The seperation of manufacturing companies in Lithuania regions

As we can see from that chart above (figure 8) which shows how divided the answers from respondents. As shown in a chart, the most significant percentage reaches 32,9 percent which belongs to the East region, the next one is the South region near the East with 31,5 percent. The last two are West region with a total of 19,2 percent and also North in the final result with 16,4 percent. All analysis results were rounded to a whole number to make more transparent about the position. The telephone survey collected this data.

All relevant information about the company's production cycles and any other relevant data collected should be taken from the respondent of the company, which has all the access to all the information we needed for this research. In the chart below it shows what kind of position people do take by answering the survey.

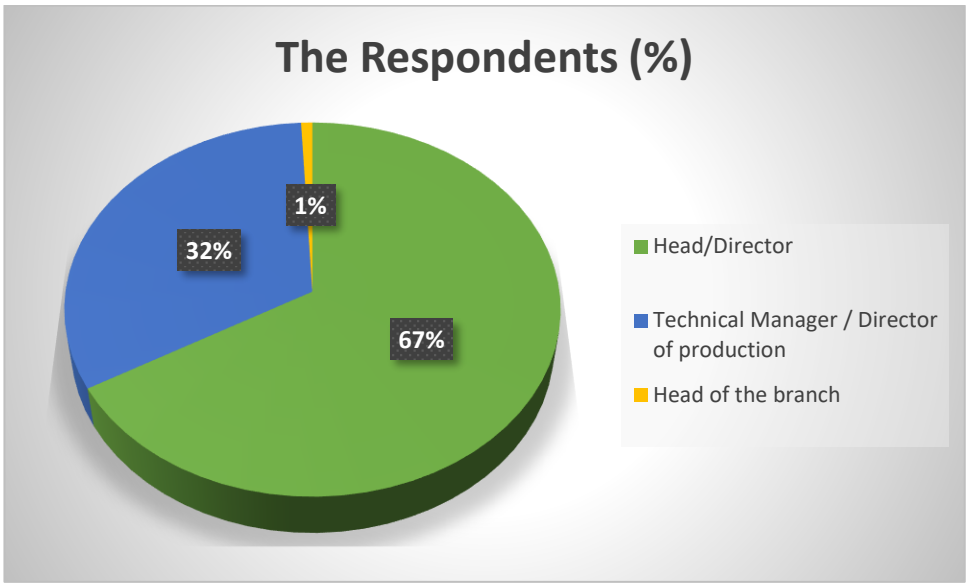

Figure 9 The results on the respondents who anwsered the questions for the reserach

As shown in this chart above (figure 9), three categories of respondents from the companies took part in this survey. The categories that did all of the questions for the companies were: Head/ director, technical manager/director of production, and head of the branch. From this measurement, we can see that the Head/director respondent's category took the most significantbiggest part for the companies with 66,7 percent of the respondents, second was the Technical manager/director of production, which took the second-highest rate 32,5 %, and the head of the branch took only 0,8 percent. All data analysis result numbers were rounded to a whole number to understanding how respondents were classified.

The study was conducted to understand better the types of businesses that exist. A chart shows what employees' number of the companies and what categories they are fitting. The search was included into four factors.

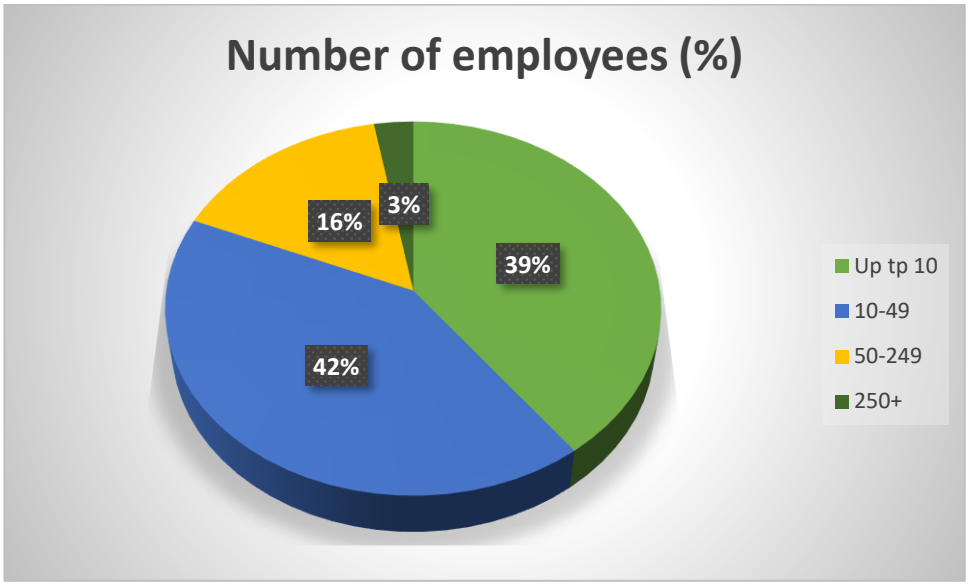

Figure 10 The result that shows company's employees number in groups

In the figure above (figure 10) it was included four categories of employee's groups that companies gave their answers for the survey:

- Micro (Up to 10 employees)
- Small (10-49 employees)
- Medium (50-249 employees)
- Large (250+ employees)

This measurement will allow a better understanding of how lean principles are diffused among the companies in Lithuania. It will determine if it's more developed in the Big companies (+250 employees), which take in Lithuania only 2,8 percent of the companies or the principles are more likely used in the lower employees numbered companies like Medium-size companies (50-249) which take in Lithuania 15,8 percent or taking the biggest part of Lithuania companies, the Small ones (1-49) which takes 41,7percent or Micro companies which take 39,7 percent of all Lithuania companies, the biggest amount of the companies in these number of employees groups. It will allow a better understanding if it is necessary to have many employees in the companies to improve the

usage of the lean manufacturing principles or promote the export policy. All analysis numbers were rounded to whole numbers to understand better how Lithuania companies are classified based on numbers of employees.

The last search of the demographical analysis is to determine what producing industries this research aims to analyze. The analysis was divided and merged at the same time to five different industries, as it is shown in the figure below (figure 11).

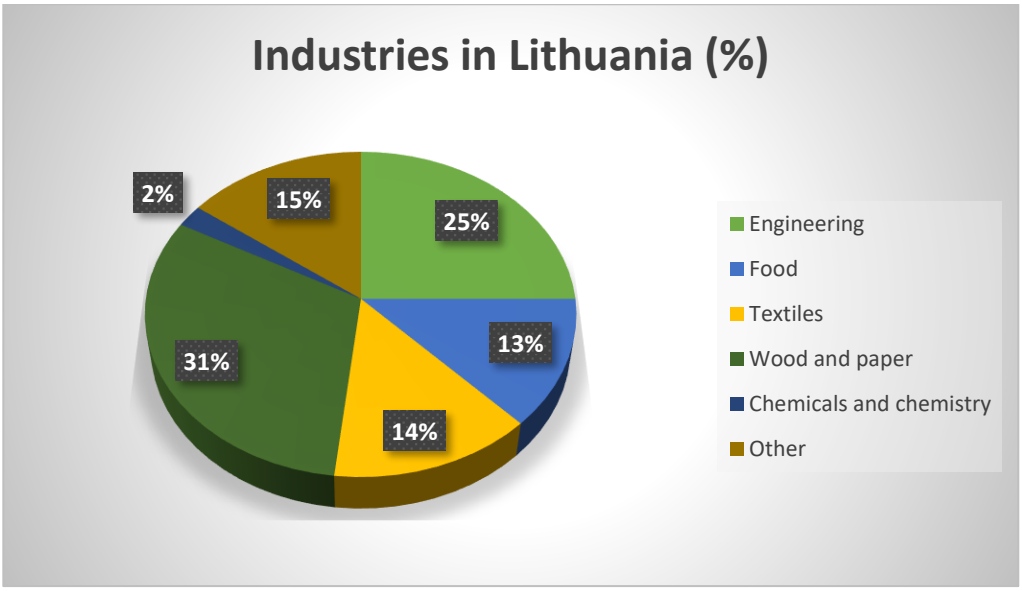

Figure 11 The result of the distribution of the indsutries alaysed in the reserach

In demographical analysis looking from industries perspective, all the companies were divided into five factors, which are shown in the figure above (figure 11):

- Engineering – to this section in the industry are assigned as a manufacturer of essential metals, electronics equipment's, fabricated metal products, machinery, and equipment n.e.c., motor vehicles, trailers and semi-trailers, other transport equipment's, repair installations.
- Food – to this section in the industry are assigned as a manufacturer of beverage, food products,
- Textiles - to this section in the industry are assigned as a manufacturer of leather and related products, rubber and plastic, textiles, non-metallic products
- Wood and paper – to this section in the industry are assigned as a manufacturer of paper and paper products, all wood manufacturing products (except furniture).
- Chemical and chemistry – this section in the industry is assigned as a manufacturer of chemicals and chemical products.
- Other – to this section in the industry are assigned as a manufacturer of IT production, wearing appearing and other manufacturing.

From the analysis shown in the figure above (figure 11) it is clear to make some assumptions about what industries are leaders in the Lithuania market and which ones are likely to have no significant interest and have a problem in development. From this, we can see that the companies who take the

enormous percent of the industry like wood and paper (31.2%) industry and engineering (25%) industry, might have a more significant development of the lean manufacturing principles, the reasons for the circumstances the companies number shows, that these industries are very competitive and have no spaces to perform negatively in the industry. When it comes to the food (12,8%), other (14,8%), and textiles (14,8%) industries, these industries take second place as the majority of production industries in the Lithuania market. These industries are the ones that could be similar to the engineering and wood with paper industries because the market is quite extensive, and the competition is high. This might mean, that companies are willing to adopt lean principles to develop the more significant efficiency and quality of the product to become the most competitive companies in Lithuania. The chemicals and chemistry (2,2%) industry is the one that takes the lowest percent of the market. This industry might have the lowest competition, and they might not be very interested in adopting the lean principles when there is such low competition in Lithuania. All analysis numbers were rounded to whole numbers to understand better how Lithuania companies are classified based on industry.

4.2. Overview the diffusion of lean production methods in Lithuania

For this section in this research, the lean production principles will be analyzed to understand and get a better accurate view of how the principles diffused among the companies in Lithuania, which are used more frequently ones still not very adopted by the production companies. These are the principles that are named below, that will be analyzed through this whole research project:

- Pull
- Continues flow
- Low setup
- Statistical process control – SPC
- Productive maintenance
- Involved employees
- Customer involvement
- Supplier development
- Supplier feedback
- Just-in-time delivery

In the questionnaire the first question related to lean production principles was that companies are using the specific principle in their company and not – are they willing to implement it till 2021. From these answers, it is customary to identify lean production methods in companies in Lithuania.

The measurement was made in two rates, the answer „yes“ and the answer „no“. In this analysis , some analysis figures have been done to understand how the principle of lean production is diffused around Lithuania, to know the potential usage of currently used principles in Lithuanian companies. The answers will be shown in linear columns, which will show the percent of respondents‘ usage, and at the bottom of the figure, there will be a table that will identify the number of the real numbers of respondents, collected with the help of this survey.

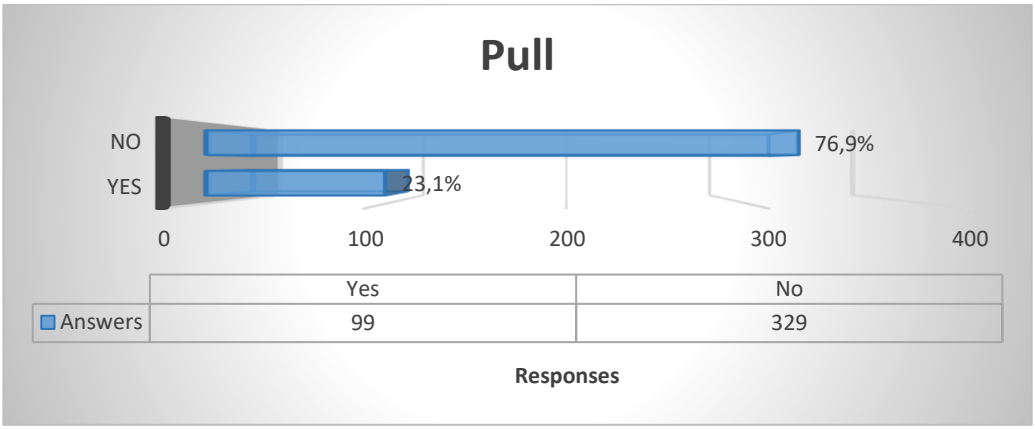

Figure 12. Number of companies that use Pull method

The first principle analyzed based on the currently used lean production methods was the pull principle, where the results are shown in the figure above (figure 12). For this principle analysis, there were 428 valid responses that companies pick “yes” or “no” answers (71 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question; for companies that use this principle, 99 (23,1%) respondents and the other 329 (76,9%) of the responses were identified negatively. From this graph, it is clear that the “Pull” principle, according to the analysis, gave more than 20% of potentially using companies.

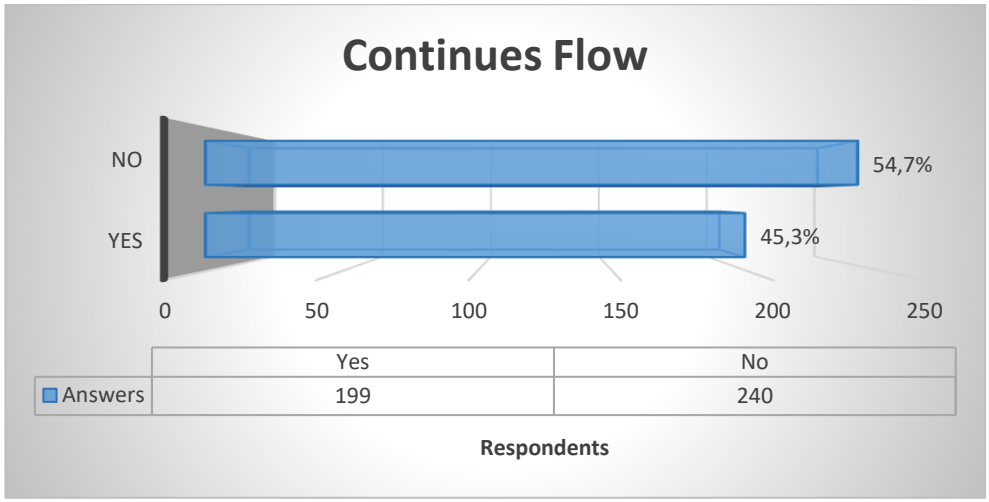

Figure 13. Number of companies that use Continues flow principle

The following principle, analyzed in this research to determine the potential usages is the continuous flow principle, where the results are shown in the figure above (figure 13). There were 439 valid answers on average for this principle that companies are using this principle in their companies‘ daily operations. This number was collected from five questions that were in this questioner that represented this question:1)the standardized and detailed work instructions, 2) measures to improve internal logistics, 3) customer - or product-orientated lines/cells in the factory, 4) detailed regulations on the arrangements and setting of the work equipment and storage of intermediary products, 5) display boards in production to illustrate work processes and work status. As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For companies that use this principle, there were 199 (45,3%) on average

respondents, and the other 240 (54,7%) of the responses were identified negatively. From this graph, it is clear that the “Continues flow” principle, according to the analysis, gave more than 40% of potentially using companies. These numbers are calculated from the calculation of 5 survey questions, because they all represent one principle, which is why these results are shown on average.

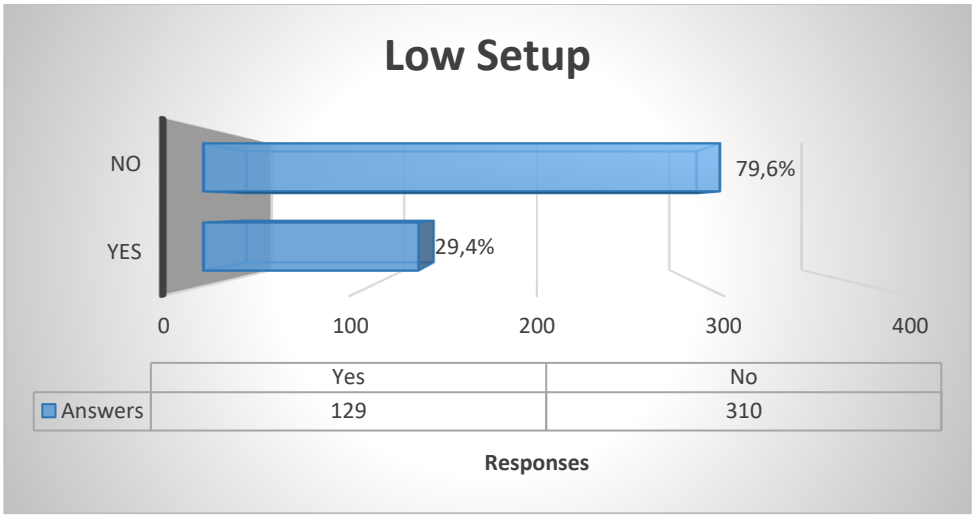

Figure 14. Number of companies that use Low setup principle

The following principle, which was analyzed based on the currently used lean production methods, was the low setup principle, where the results are showing in the figure above (figure 14). For this principle analysis, there were 439 valid responses that companies pick “yes” or “no” answers (60 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For the companies that use this principle, 129 (29,4%) respondents and the other 310 (79,6%) of the responses were identified negatively. From this graph, it is clear that the “Low setup” principle, according to the analysis, gave more than 20% of potentially using companies.

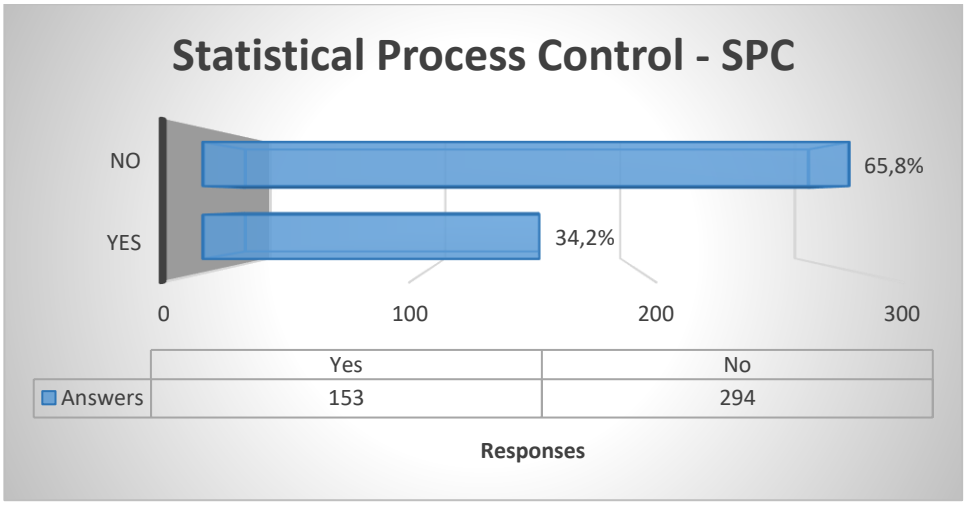

Figure 15. Number of companies that use SPC principle

The following principle, which was analyzed based on the currently used lean production methods, was the SPC-statistical process control principle, where the results are showing in the figure above

(figure 15). For this principle analysis, there were 447 valid responses that companies pick “yes” or “no” answers (52 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For the companies that use this principle, `153 (34,2%) respondents and the other 294 (65,8%) of the responses were identified negatively. From this graph, it is clear that the “Statistical process control” principle, according to the analysis, gave more than 30% of potentially using companies.

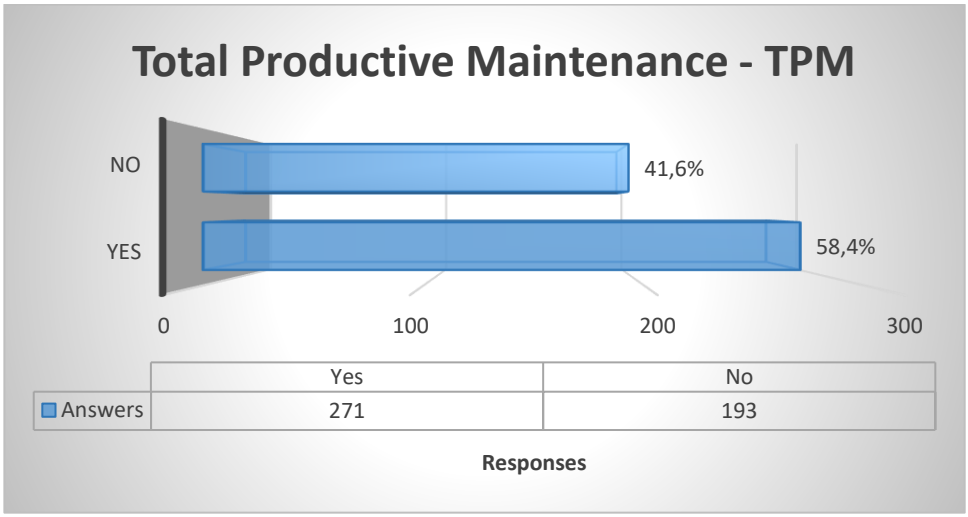

Figure 16. Number of companies that use TPM principle

The following principle, which was analyzed based on the currently used lean production methods, was the total productive maintenance (TPM) principle, where the results are showing in the figure above (figure 16). For this principle analysis, there were 464 valid responses that companies pick “yes” or “no” answers (35 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For the companies that use this principle, 271 (58,4%) respondents and the other 193 (41,6%) of the responses were identified negatively. From this graph, it is clear that the “TPM” principle, according to the analysis, gave more than 50% of potentially using companies.

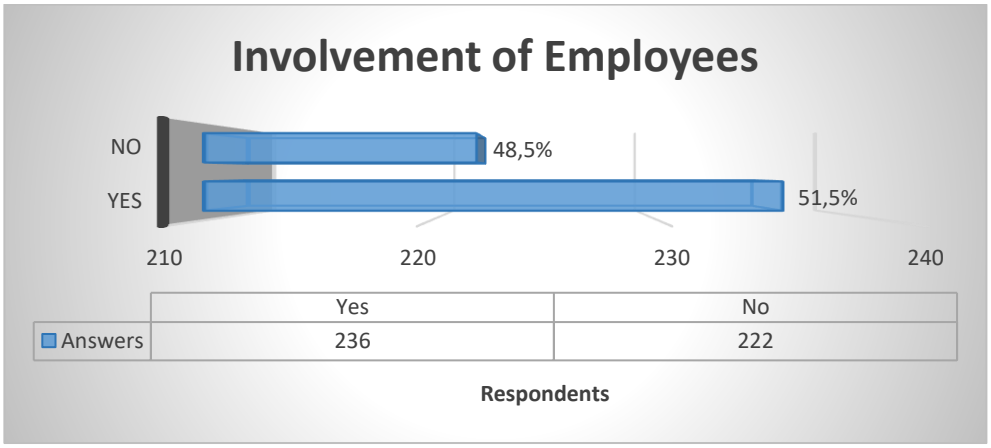

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Figure 17. Number of companies that use Involvement of employees principle

The following principle, analyzed in this research to determine the potential usages is the involvement of employees principle, where the results are shown in a figure above (figure 17). There were 458

valid answers on average for this pronciple that companies are using this principle in their companies‘ daily operations. This number was collected from two questions in this questioner that represented this question: 1) Involvement of employees into improvement, 2) integration of tasks. As it was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For companies that use this principle, 236 (51,5%) on average respondents and the other 222 (48,5%) of the responses were identified negatively. From this graph, it is clear that the “Involvement of employees” principle, according to the analysis, gave more than 50% of potentially using companies. These numbers are obtained from the calculation of 2 survey questions because they represent one principle: these results are showing on average.

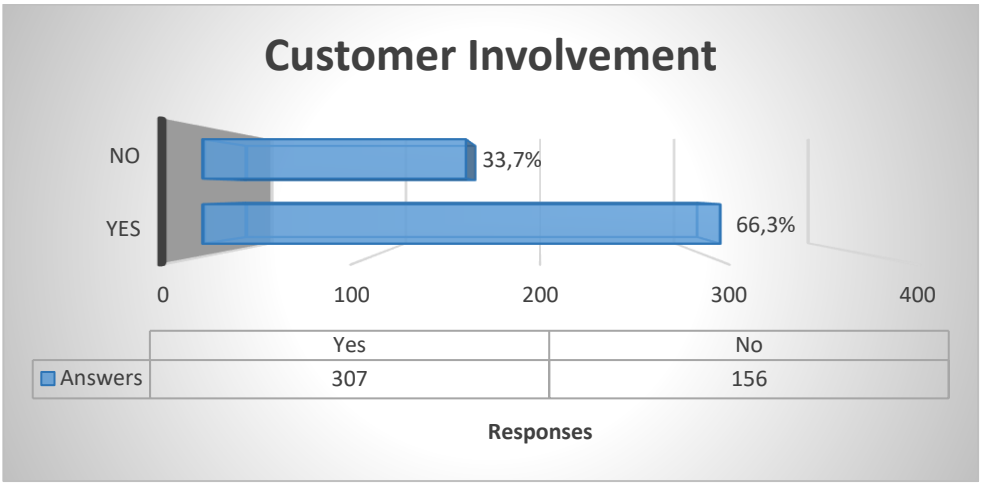

Figure 18. Number of companies that use Customer involvement principle

The following principle, which was analyzed based on the currently used lean production methods, was the customer involvement principle, where the results are showing in the figure above (figure 18). For this principle analysis, there were 463 valid responses that companies pick “yes” or “no” answers (36 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For the companies that use this principle, 307 (66,3%) respondents and the other 156 (33,7%) of the responses were identified negatively. From this graph, it is clear that the “Customer Involvement” principle, according to the analysis, gave more than 60% of potentially using companies.

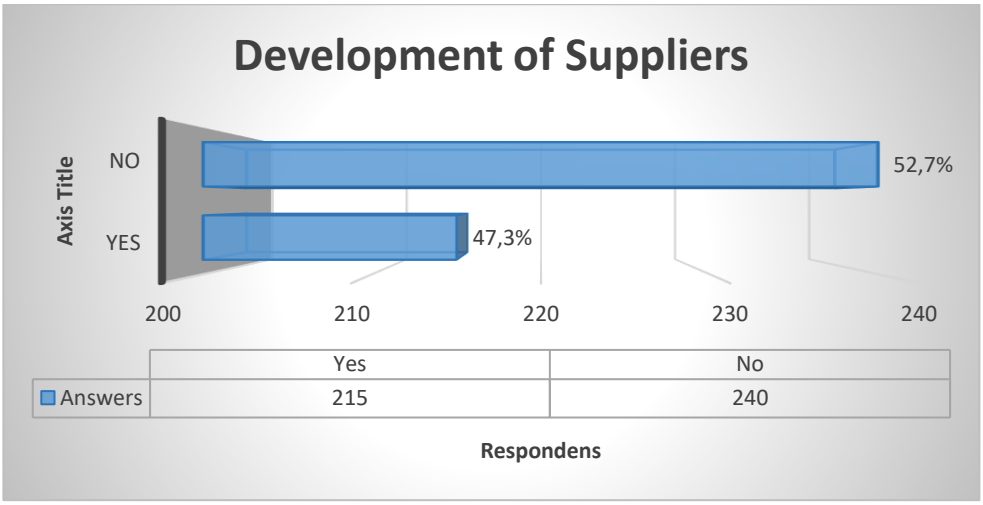

Figure 19. Number of companies that use Development of suppliers principle

The following principle, which was analyzed based on the currently used lean production methods, was the development of suppliers principle, where the results are showing in the figure above (figure 19). For this principle analysis, there were 455 valid responses that companies pick “yes” or “no” answers (44 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For the companies that use this principle, 215 (47,3%) respondents and the other 240 (52,7%) of the responses were identified negatively. From this graph, it is clear that the “Development of Suppliers” principle, according to the analysis, gave more than 40% of potentially using companies.

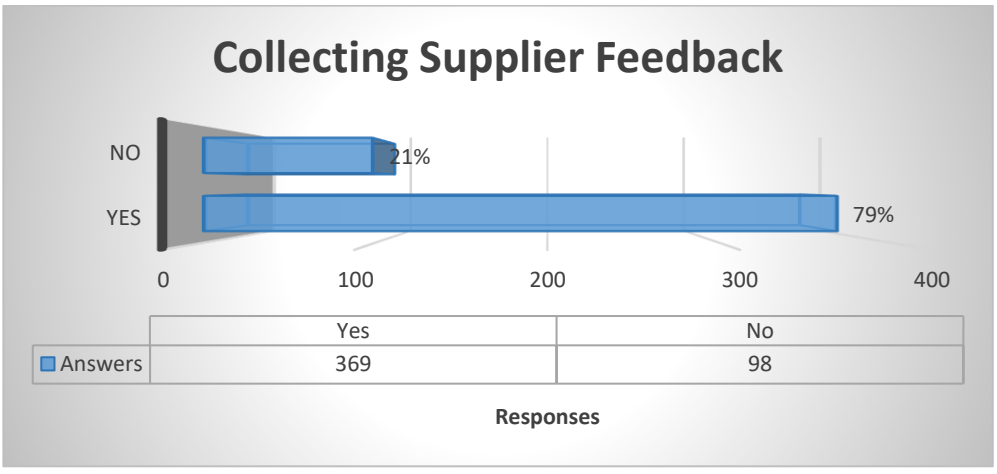

Figure 20. Number of companies that use Collecting supplier feedback principle

The following principle, which was analyzed based on the currently used lean production methods, was the collecting supplier feedback principle, where the results are showing in the figure above (figure 20). For this principle analysis, there were 467 valid responses that companies pick “yes” or “no” answers (32 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For the companies that use this principle, 369 (79%) respondents and the other 98 (21%) of the responses were identified negatively. From this graph, it is clear that the

"Collecting Supplier Feedback" principle, according to the analysis, gave more than 70% of potentially using companies.

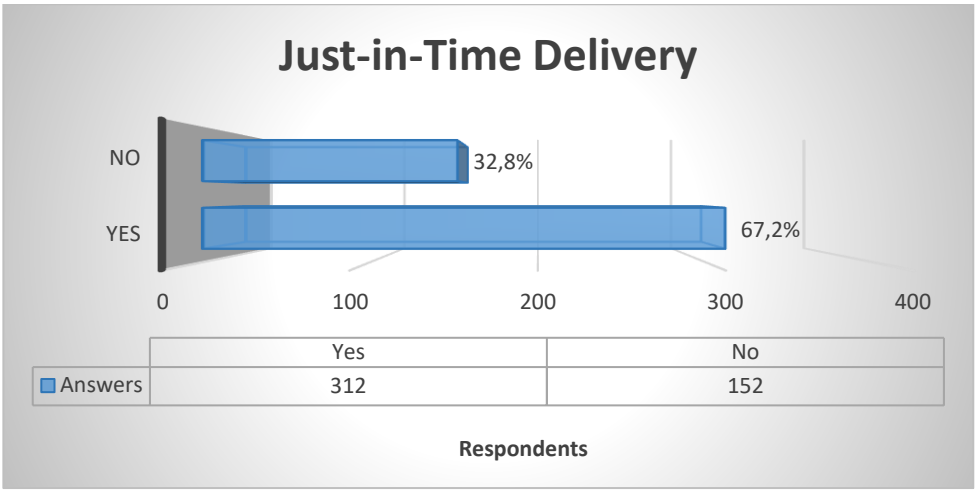

Figure 21. Number of companies that use JIT principle

The following principle, which was analyzed based on the currently used lean production methods, was the just in time delivery principle, where the results are showing in the figure above (figure 21). For this principle analysis, there were 464 valid responses that companies pick "yes" or "no" answers (35 companies did not give any response to this survey question). As was explained before, this measurement will show if a company is using this principle or not. There were two options to answer this question. For the companies that use this principle, 312 (67,2%) respondents and the other 152 (32,8%) of the responses were identified negatively. From this graph, it is clear that the "Just-in-Time Delivery" principle, according to the analysis, gave more than 60% of potentially using companies.

The research results of currently used methods in Lithuania the figure below (figure 22) show the current situation what methods are primarily used in Lithuanian companies. Talking from the perspective of the lean production principles currently the usage of the companies the results have shown that the „Collecting supplier feedback "takes the biggest numbers 79% as the most used method in Lithuania, the second and third place methods „Just-in-Time delivery ", and „Customer involvement) are quite equal, which variants at 66-67%. The least used method which has the lowest diffusion in Lithuania is the "pull" principle (23,1%). This shows that the popularity of the methods is quite diffused and used unevenly. Because the most used method is almost 80% and the least used method only reaches 23% of currently used methods.

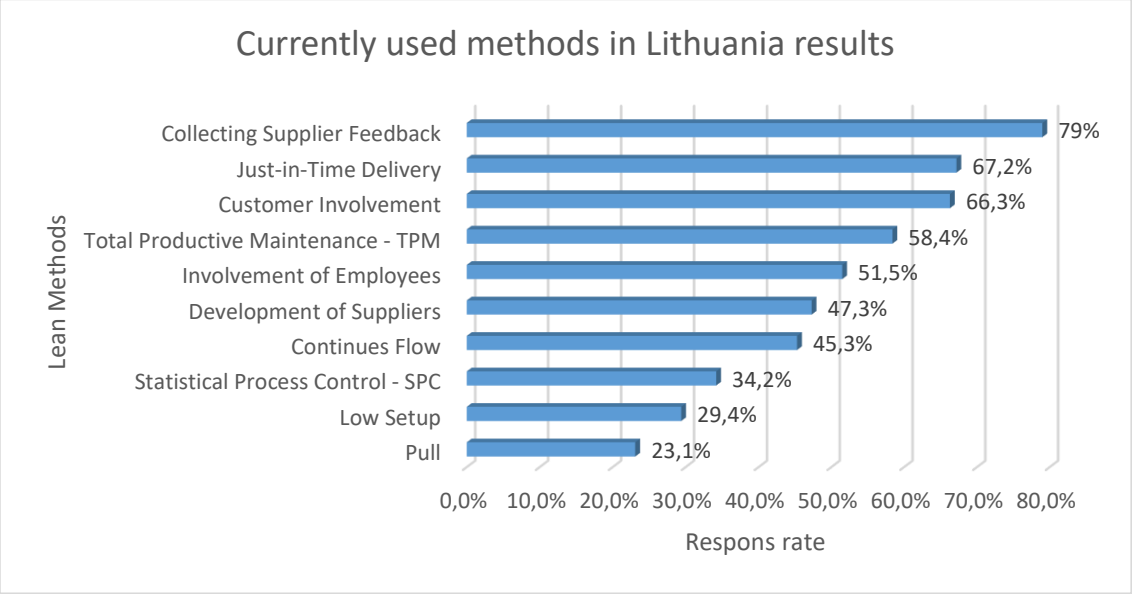

Figure 22 The results of currently used lean methods in Lithuania

For the next issue, the extent of used potential will be evaluated on lean methods in Lithuania to determine if the lowest used methods do bring the lowest value or the highest used methods do bring the most significant values to the companies.

4.3. The extent of used potential of lean methods

In this chapter, it will be analyzed the separated lean manufacturing principles. It will be evaluated the potential usage of lean production principles from low to high to get a better understanding of how Lithuanian companies are using them and how the diffusion is affected through the companies of production in Lithuania.

Lean production principles that will be analyzed:

- Pull
- Continues flow
- Low setup
- Statistical process control – SPC
- Productive maintenance
- Involved employees
- Customer involvement
- Supplier development
- Supplier feedback
- Just-in-time delivery.

In the questionnaire, the first question that was analyzed as if the companies are using the lean production methods, the answer was yes or no, if not is it planning to be used until 2021, if yes, the year it was installed or used. The second part of this question was to identify the lean production methods as their impact on the company and does it bring value to the company:

- Low – not much effect has happened after the implementation of the method

- Medium – the company is satisfied with the principles with the added value.
- High – company is delighted with the impact of lean production methods and made a big difference in the manufacturing process.

The measurement was done in three categories as it was mentioned before – low, medium, high. In this research, several figures for all the lean production principles from the survey to get a better understanding of how companies in Lithuania use these principles individually. It will be known which lean production methods are widely adopted in Lithuania, and which ones are still underutilized. The figures, show the analyzed result on to we can see the principle the result is representing. There is an easily understandable frequency numbers liner graph with three columns representing the low, medium, high scales. Next to scales, there is a percent indicator that shows how the principle is used among the companies that answered this survey. At the bottom, there is a small table which shows the actual numbers of respondents that currently are using lean production principles, to understand the difference between the percentage and real numbers, to be precise, to get closer to the situation of this principle that will be shown in a figure.

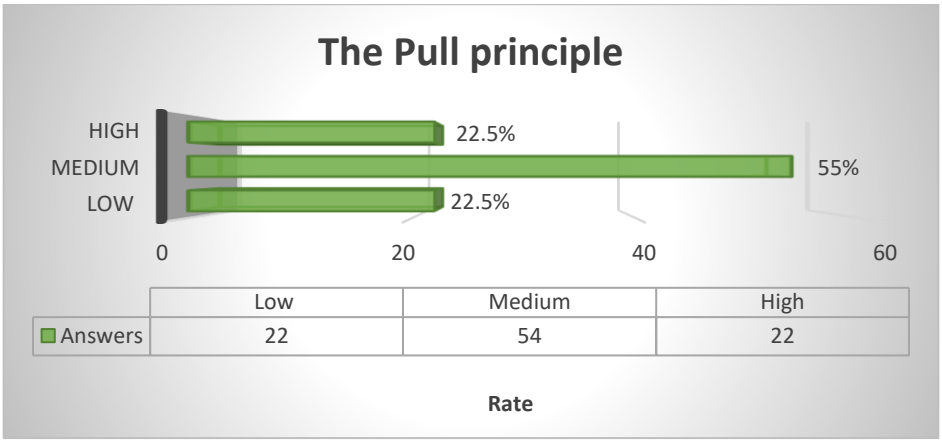

Figure 23. Potential usage following the Pull principle analysis

The research on the potential usage of lean principles will start with the Pull principle (figure 23). It was received that 98 valid answers that companies are currently using this lean principle (400 number of companies mentioned that is not currently using this principle). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 22 respondents, medium – 54 and high 22 respondents. From this graph, we can say that the ,,Pull‘‘ principle, according to the analysis, gave more than 50% percent medium value to the production cycle.

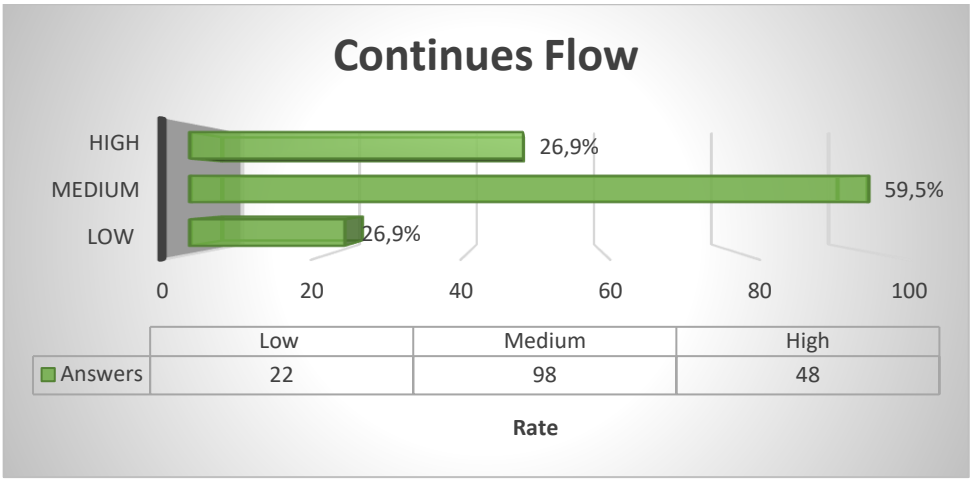

Figure 24. Potential usage following the continues flow principle analysis

The following principle analyzed in this research to determine the potential usages is the continuous flow principle, where the results are shown in the figure above (figure 24). There were 168 valid answers on average for this principle that companies are using this principle in their companies‘ daily operations. This number was collected from five questions that were in this questioner that represented this question:1)the standardized and detailed work instructions, 2) measures to improve internal logistics, 3) customer - or product-orientated lines/cells in the factory, 4) detailed regulations on the arrangements and setting of the work equipment and storage of intermediary products, 5) display boards in production to illustrate work processes and work status. (168 on an average number of companies mentioned, that is not currently using this principle). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 22 on average respondents (26,9%), medium – 98 (59,5%) and high 48 (26,9%) respondents. From this graph, we can say that the ,,Continues flow‘‘ principle, according to the analysis, gave near to 60% percent medium value to the production cycle. These numbers are calculated from the calculation of 5 survey questions, because they all represent one principle, which is why these results are shown on average.

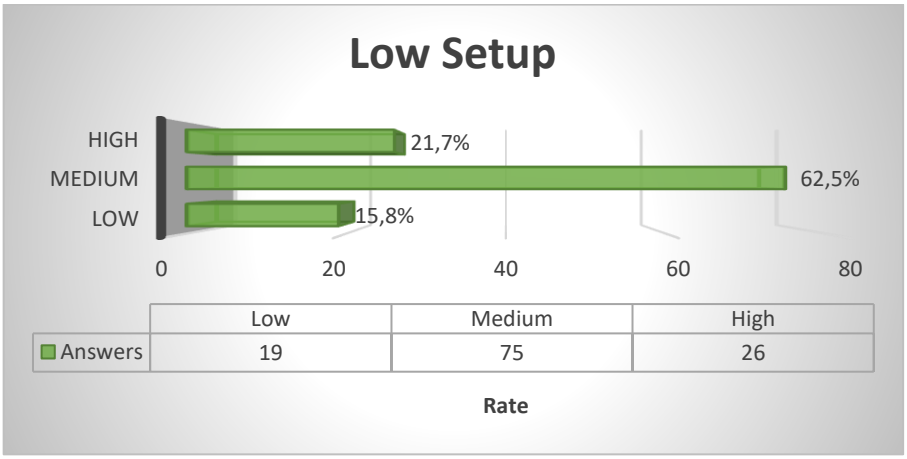

Figure 25. Potential usage following the low setup time principle analysis

The following principle analyzed in this research to determine the potential usages is the low setup principle, where the results are showing in the figure above (figure 25). There were 120 valid answers for this principle that companies are using this principle in their companies‘ daily operations (370

number of companies mentioned that is not currently using this method). As it was explained at the beginning, the measurement was included in three different graphs, that in this method the result showed, that principle gave low value to 19 respondents (15,8%), medium – 75 (62,5%) and high 26 (21,7%) respondents. From this graph, we can say that the ,,Low setup time‘‘ principle according to the analysis, gave more than 60% percent medium value to the production cycle.

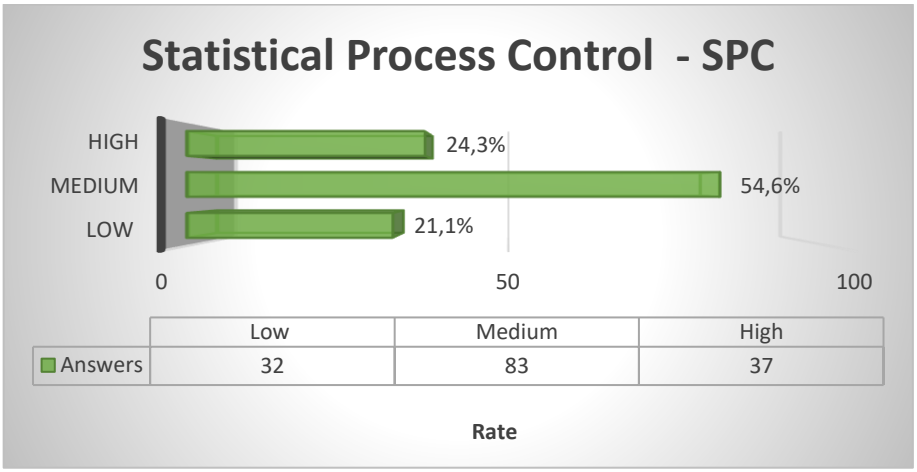

Figure 26. Potential usage following the SPC principle analysis

The following principle analyzed in this research to determine the potential usages is the statistical process control (SPC) principle, where the results are showing in the figure above (figure 26). There were 152 valid answers for this principle that companies are using this principle in their companies‘ daily operations (362 number of companies mentioned that is not currently using this method). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 32 respondents (21,1%), medium – 83 (54,6%) and high 37 (24,3%) respondents. From this graph, we can say that the ,,SPC‘‘ principle according to the analysis, gave more than 50% percent medium value to the production cycle.

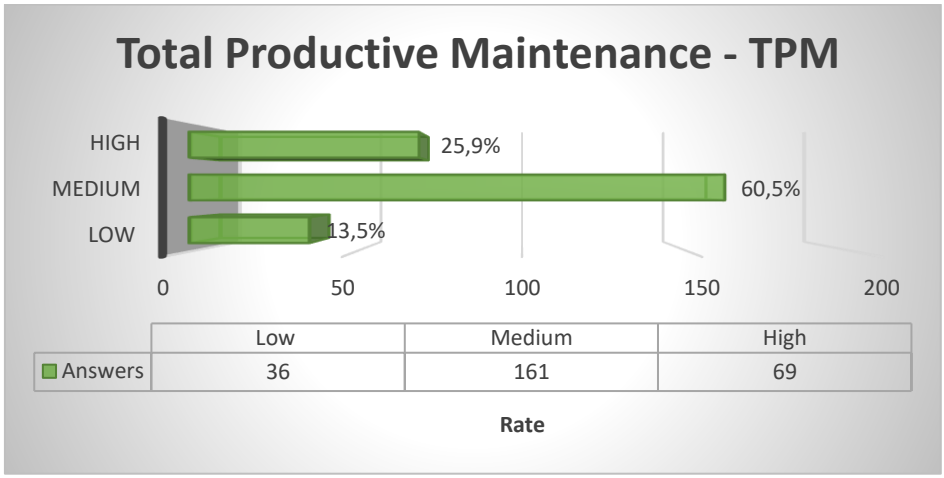

Figure 27. Potential usage following the TPM principle analysis

The following principle analyzed in this research to determine the potential usages is the total productive maintenance (TPM) principle, where the results are showing in the figure above (figure 27). There were 266 valid answers for this principle that companies are using this principle in their

companies‘ daily operations (228 number of companies mentioned that is not currently using this method). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 36 respondents (13,5%), medium – 161 (60,5%) and high 69 (25,9%) respondents. From this graph, we can say that the ,,TPM‘‘ principle according to the analysis, gave more than 60% percent medium value to the production cycle.

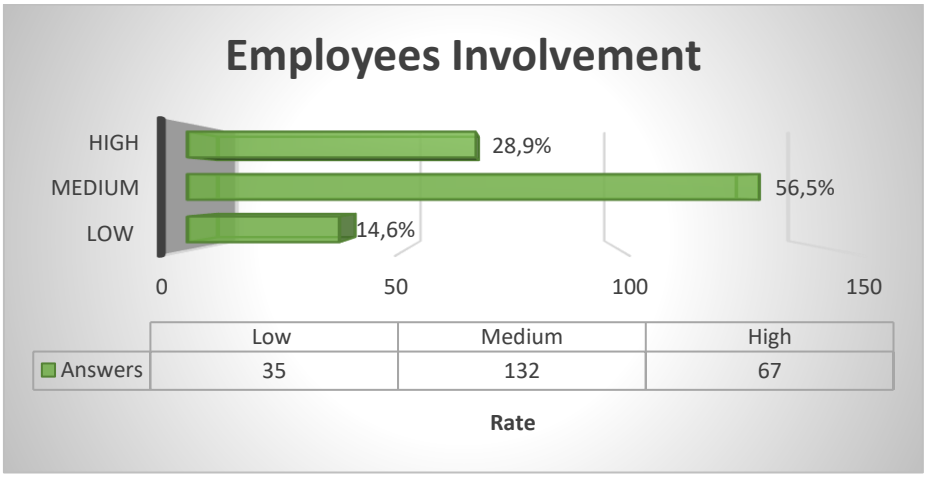

Figure 28. Potential usage following the employees involvement principle analysis

The following principle, analyzed in this research to determine the potential usages is the employee‘s involvement principle, where the results are shown in the figure above (figure 28). There were 234 valid answers on average for this principle that companies are using this principle in their companies‘ daily operations. This number was collected from two questions: in this questioner that represented this question:1) Involvement of employees into improvement, 2) integration of tasks, (265 an average number of companies mentioned, that are not currently using this principle). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 35 on average respondents (14,6%), medium – 132 (56,5%) and high 67 (28,9%) respondents. From this graph, we can say that the ,,Employees involvement‘‘ principle, according to the analysis, gave near to 60% percent medium value to the production cycle. These numbers are obtained from the calculation of 2 survey questions, because they all represent one principle, which is why these results are average.

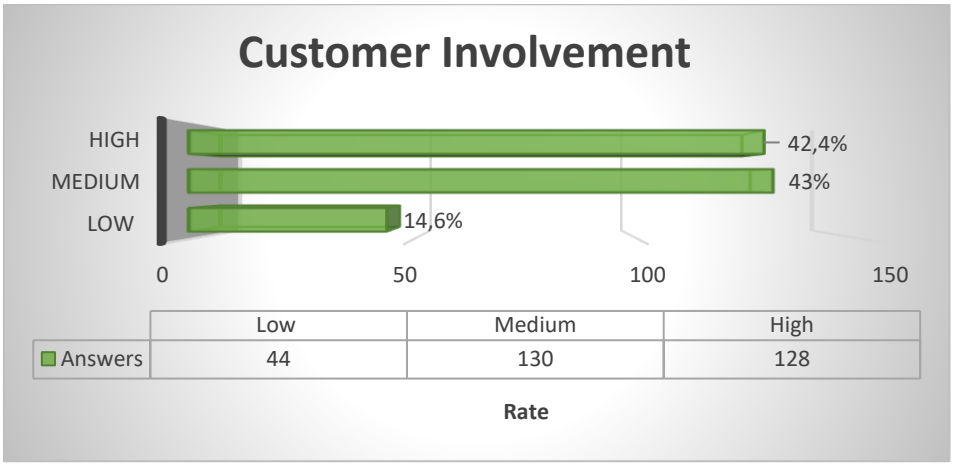

Figure 29. Potential usage following the customer involvement principle analysis

The following principle analyzed in this research to determine the potential usages is the customer involvement principle, where the results are showing in the figure above (figure 29). There were 302 valid answers for this principle that companies are using this principle in their companies‘ daily operations (192 number of companies mentioned that is not currently using this method). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 44 respondents (14,6%), medium – 130 (43%) and high 128 (42,4%) respondents. From this graph, we can say that the ,,Customer Involvement‘‘ principle according to the analysis, gave more than 40% percent medium value to the production cycle.

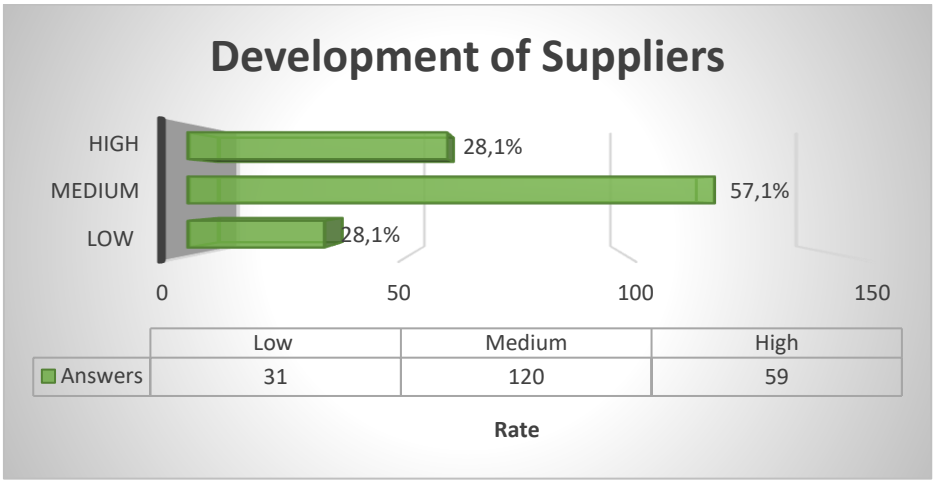

Figure 30. Potential usage following the development of suppliers principle analysis

The following principle analyzed in this research to determine the potential usages is the development of suppliers principle, where the results are showing in the figure above (figure 30). There were 210 valid answers for this principle that companies are using this principle in their companies‘ daily operations (284 number of companies mentioned that is not currently using this method). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 31 respondents (28,1%), medium – 120 (57,1%) and high 59 (57,1%) respondents. From this graph, we can say that the ,,Development of Suppliers‘‘ principle according to the analysis, gave more than 50% percent medium value to the production cycle.

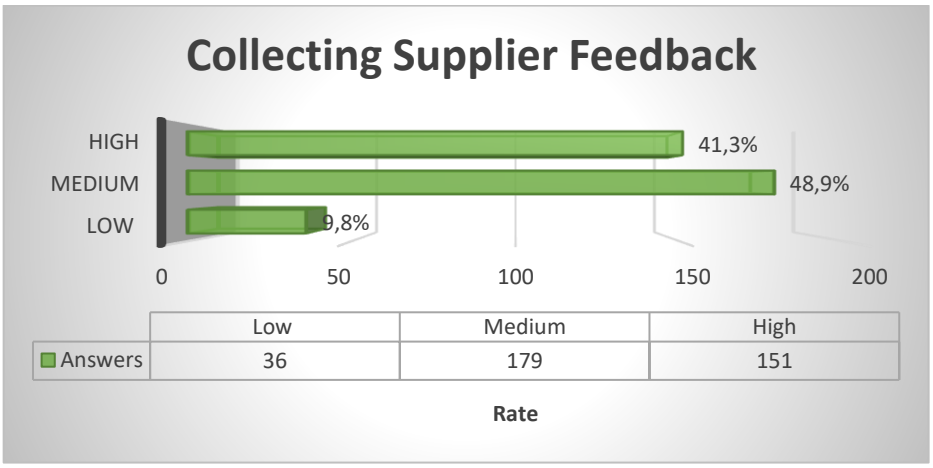

Figure 31 Potential usage following the collecting supplier feedback principle analysis

The following principle analyzed in this research to determine the potential usages is the collecting supplier feedback principle, where the results are showing in the figure above (figure 31). There were 366 valid answers for this principle that companies are using this principle in their companies‘ daily operations (130 number of companies mentioned that is not currently using this method). As it was explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 36 respondents (9,8%), medium – 179 (48,9%) and high 151 (41,3%) respondents. From this graph, we can say that the ,,Collecting Supplier Feedback‘‘ principle according to the analysis, gave more than 40% percent medium value to the production cycle.

Also, the high rate of adding value to the companies cycles based on this principle was more than 40%, which does show that this principle is very used among the companies in Lithuania and is adding a significant value to companies operations.

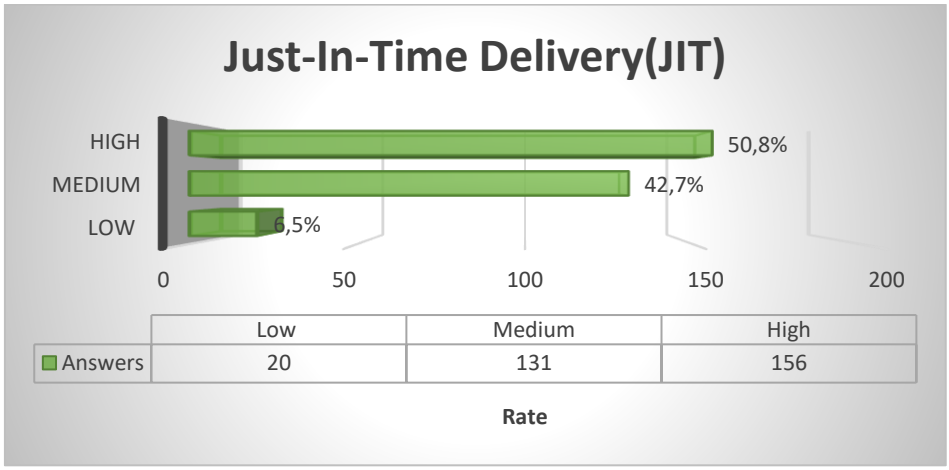

Figure 32. Potential usage following the JIT principle analysis

The following principle analyzed in this research to determine the potential usages is the Just-In-Time delivery (JIT) principle, where the results are shown in the figure above (figure 32). There were 307 valid answers for this principle that companies are using this principle in their companies‘ daily operations (187 number of companies mentioned that is not currently using this principle). As it was

explained at the beginning, the measurement was included in three different graphs, that in this principle the result showed, that principle gave low value to 20 respondents (6,5%), medium – 131 (42,7%) and high 156 (50,8%) respondents. From this graph, we can say that the ,,Just-In-Time delivery‘‘ principle, according to the analysis, gave more than 50% percent with high value to the production cycle. This is the only principle that was rated the highest in adding value to the companies operations.

From this analysis, it is clear that there are three dominating principles in the potential usage of lean production methods. The most used method, according to the respondents, was the collecting supplier feedback method. This method had 366 valid answers, not depending on the low, medium, and high rate that companies rated them. The second and the third place in usage was the Just-In-Time delivery (307) and customer involvement method (302). According to the result, it is already seen that these two principles are pretty equal to the answers numbers, but what is quite interesting the rating results are pretty similar as well, which we can see in the figures above (figure 15 &18). From the analysis of potential usage and the adding value, these three methods were popped like leaders in the Lithuania industry as the most adopted principles. This shows that the principles like “pull” or “low setup” still lack popularity in the Lithuanian companies, which might be the consequence of not many skills, level of knowledge of the machines is not very efficient. This analysis outlined the current diffusion in the Lithuania market, which from the first, there was no type of diffusion, but the analysis numbers show it differently.

The extent of the used potential of lean methods was evaluated in calculating the average rate which the lowest point was 1 and the highest 3 (figure 33). The most significant adding value for the companies is “Just-in-Time” delivery lean methods, which had an average rate of 2,4. For the second place, the “Collecting supplier feedback” lean method with the 2,3 rates. These principles are the ones that are most widely used, and they have the most significant impact on the company’s everyday task. The principles adding value show a different story than the currently used methods. The ones who looked the least popular in the currently used section could bring more considerable value for the companies than the more popular methods.

Comparing the currently used results (figure 22) and these extent of used potential results (figure 33) it is precise that adding values does not equal the number of used methods. The diffusion of lean methods will be evaluated from other factors to see what stimulates the diffusion of lean methods.

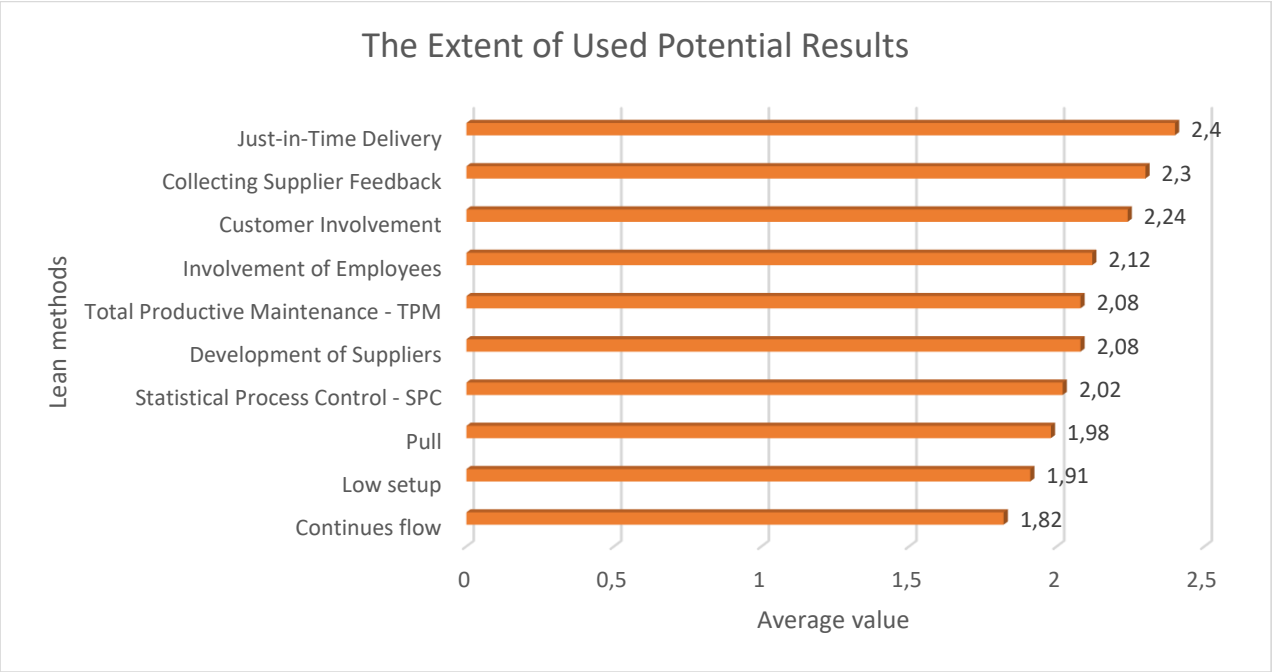

Figure 33 The results of extent of used potential

For the subsequent evaluation, it will be analyzed whether the export is the factor that determines a more extensive usage of lean methods than non-exporting companies and is it a factor that brings the diffusion of lean methods in the companies.

4.4. The analysis of the diffusion of lean production based on the whether company is exporting or non-exporting

The SPPS application was used to process the data file and recognize how the export affects lean techniques diffusion to see if there is a significant difference in how exporting firms and non-exporting enterprises adopt lean approaches.

In the figure below (figure 34) it is shown a histogram with the frequency results, which are shown in percentages to represent the lean production methods diffusion based on the exporting and non-exporting companies. There are 20 columns, representing each lean production method mentioned on the left side of the graph. Every principle has a result-based from exporting companies (Exporting) and non-exporting companies (Non-Exporting). The results only were structured from the valid answers. The companies that did not leave any response if they are exporting or using specific principle were not involved in the analysis. The analysis result is shown in percentage value to get a better understanding of how to lean principle diffuse based on export.

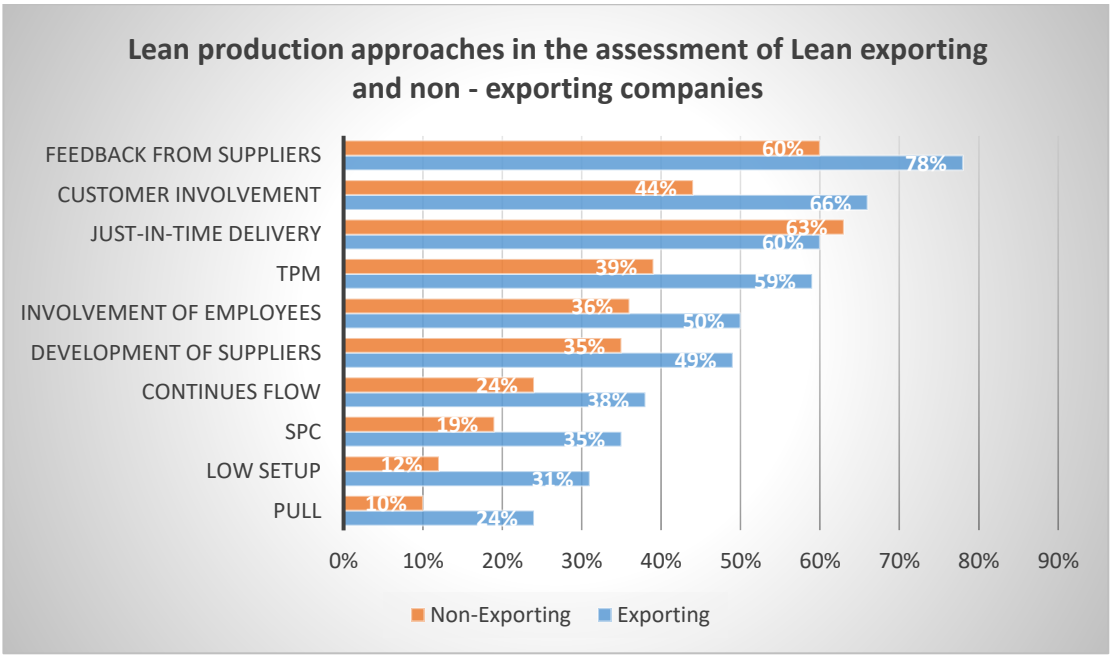

Figure 34. Results of the analysis based on exporting and non-exporting comapnies

To review the results shown in the figure above (figure 34) it is pretty clear that exporting companies use more frequently lean methods than non-exporting companies. Only the Just-in-Time, lean methods did not show any significantly precise results that would help to make any assumptions. The exporting companies, on average, are using lean methods more than 10 % than non-exporting companies, which is a big and significant difference that could determine that export is the factor that stimulates the diffusion of lean methods in the country.

To see if the lean methods are affected by the rate at which they are exported, the Pearson chi-square test used to see if the hypothesis that lean methods are more likely to be used by the exporting than the non-exporting companies, thus leading to a more extensive diffusion of lean methods is confirmed or rejected by the results done from the test.

Pearson chi-square summary that p-value (Asymptotic Significance) does show the depending on the lean method to the exporting factor. If the p-value is higher than 0,05 ,then the hypothesis is rejected. The results of the test are shown in Table 3:

Table 3. Signification between lean methods and exporting activities (made by author)

Lean methods	P value (Asymptotic Significance)
Pull	**0,001**
Flow	0,073
Low Setup	**0,001**
SPC – Statistical Process Control	**0,002**
TPM – Total Productive Maintenance	**0,002**
Involvement of Employees	0,461
Customer involvement	**0,002**
Developments od Suppliers	**0,037**
Collecting Supplier Feedback	**0,005**
Just-in-Time Delivery	0,128

After the test is done, the results show (Table 3) how the lean methods depend on the exporting activities. The hypothesis is confirmed that lean methods are more likely to be used by the exporting companies than non-exporting companies because most lean methods have a considerable dependent value from the export activities. All mentioned before, lean methods have a lower p-value rate than 0.05, which shows that methods are dependent on the export. The methods "Flow" and "Involvement of employees" can not be made as an assumption that they are not dependent, because they were concluded from more than one method, which ones showed that methods are dependent on each other and other showed that they are not, all results will be shown in appendices section (Appendix 1).

Talking from the perspective of the "Just-in-Time Delivery" lean method, as the results are shown from the frequency analysis (Figure 34), it does show that this lean methods p-value is over 0.05 limit which reaches 0,1278, and by doing the test, it is easy to assume that Just-in-time delivery lean method is independent of exporting activities and does not give any impact due to uneven lean methods diffusion in Lithuania companies.

All in all, the hypothesis is confirmed that the lean method diffusion is dependant on exporting activities because the p values showed that the activities of export influence more than 70% of lean methods.

4.5. The analysis of the diffusion of lean production based on company‘s size

This chapter will be evaluated how the lean methods are diffused, evaluating different companies ‘sizes. The chart analysis is made for all ten lean methods with the four columns. The columns were made based on the companies ‘sizes. The value MICRO seen in the chart has the value up to 10 employees in the company. The SMALL value represents 10-49 employees that are working in the company. The third value, MEDIUM, represents the companies with the employees ‘number from 50 to 249. Furthermore, the last value LARGE shows the most prominent companies that are 250 and above, and this means that there is no limit when talking about the biggest companies in Lithuania.

The figures (35-44) below will show how lean methods are diffused based on the company ‘s size.

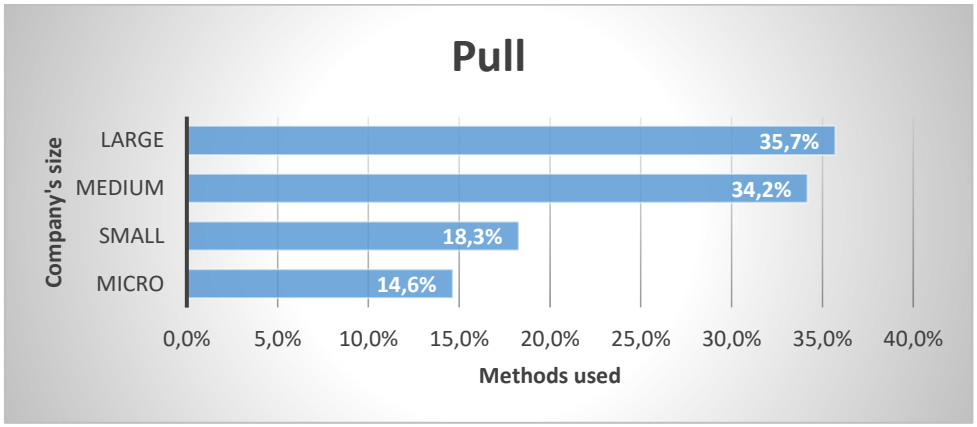

Figure 35 The results of „Pull“ principle diffusion based of company’s size

In the figure above (figure 35), the result shows lean method diffusion analysis done on the “Pull” principle with four categories of company’s sizes. The figure shows that large companies (LARGE) use this principle 35,2%, medium (MEDIUM) 34,2%, small (SMALL) uses 18,3% and micro (MICRO) uses only 14,6%. The highest usage of lean methods is among large size companies, which rate was almost 36%.

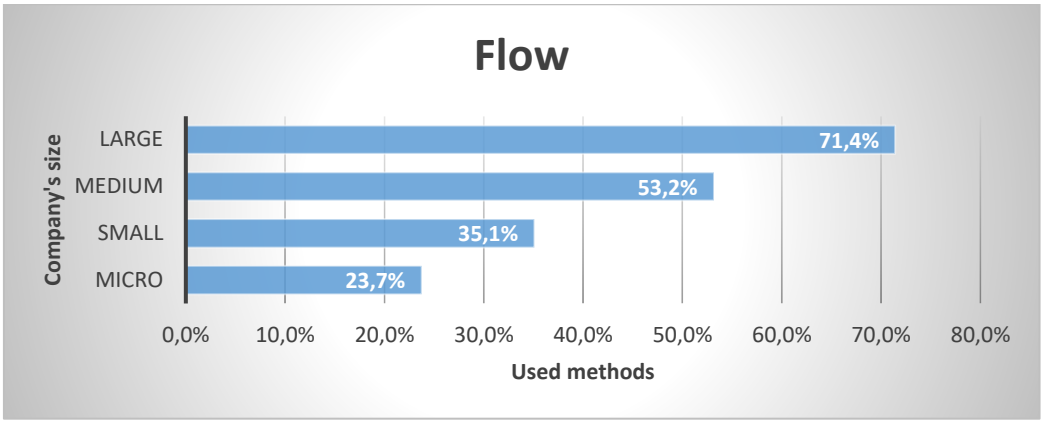

Figure 36 The results of „Flow“ principle diffusion based of company’s size

In the figure above (figure 36), the result shows lean method diffusion analysis done on the “Flow” principle with four categories of company’s sizes. The figure shows that large companies (LARGE) use this principle 71,4%, medium (MEDIUM) 53,2%, small (SMALL) uses 35,1% and micro (MICRO) uses only 23,7%. The highest usage of lean methods is among large size companies, which rate was almost 72%.

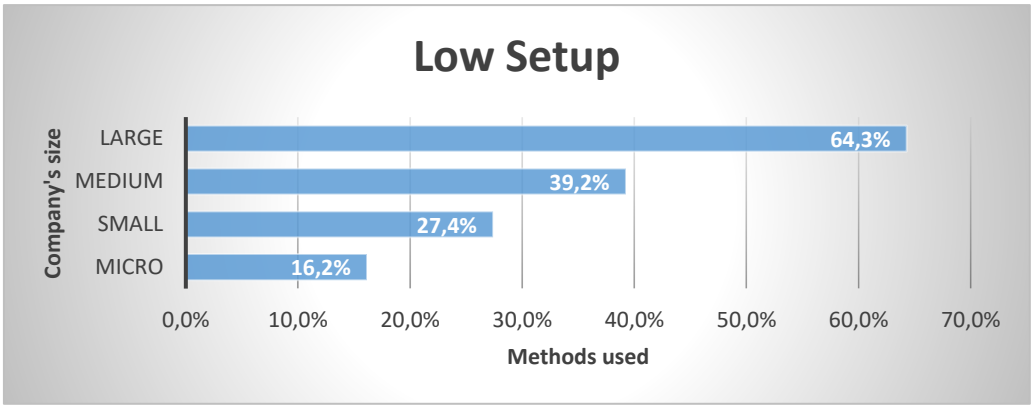

Figure 37 The results of „Low setup“ principle diffusion based of company’s size

In the figure above (figure 37), the result shows lean method diffusion analysis done on the “Low setup” principle with four categories of company’s sizes. The figure shows that large companies (LARGE) use this principle 64,3%, medium (MEDIUM) 39,2%, small (SMALL) uses 27,4% and micro (MICRO) uses only 16,2%. The highest usage of lean methods is among large size companies, which rate was almost 65%.

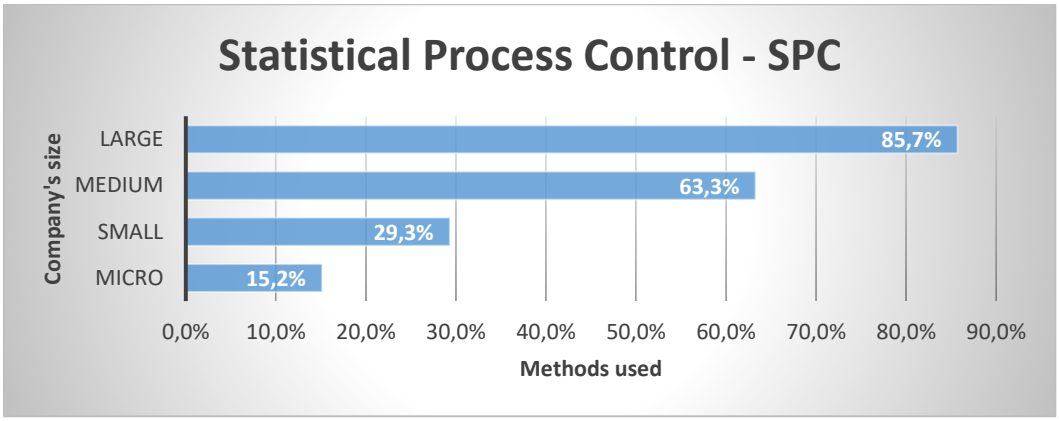

Figure 38 The results of „Statistical Process Control - SPC“ principle diffusion based of company's size

In the figure above (figure 38), the result shows lean method diffusion analysis done on the "Statistical Process Control - SPC" principle with four categories of company's sizes. The figure shows that large companies (LARGE) use this principle 85,7%, medium (MEDIUM) 63,3%, small (SMALL) uses 29,3% and micro (MICRO) uses only 15,2%. The highest usage of lean methods is among large size companies, which rate was almost 86%.

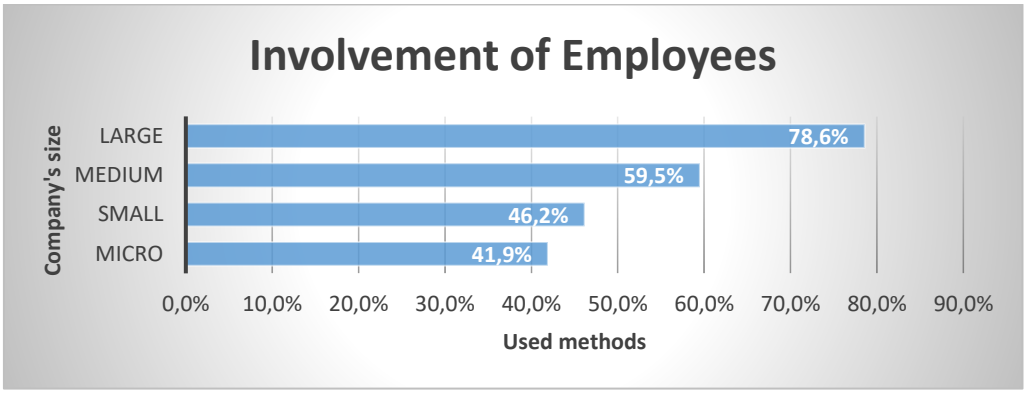

Figure 39 The results of „Involvement of Employees“ principle diffusion based of company's size

In the figure above (figure 39), the result shows lean method diffusion analysis done on the "Involvement of Employees" principle with four categories of company's sizes. The figure shows that large companies (LARGE) use this principle 78,6%, medium (MEDIUM) 59,5%, small (SMALL) uses 46,2% and micro (MICRO) uses only 41,9%. The highest usage of lean methods is among large size companies, which rate was almost 79%.

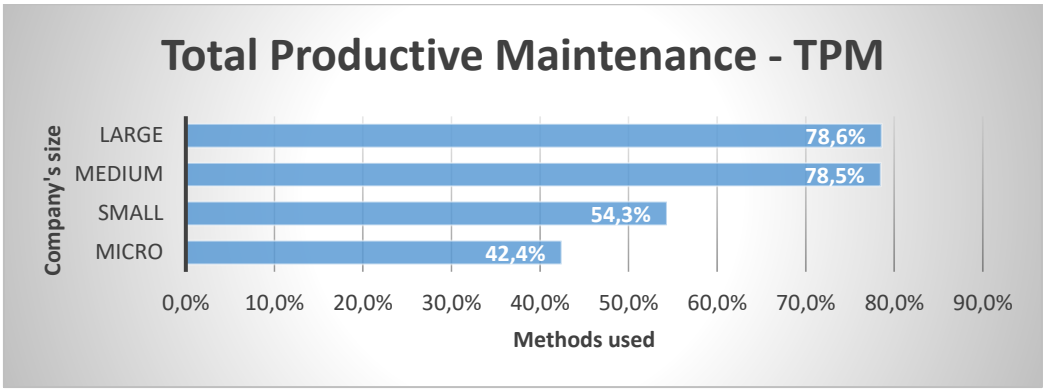

Figure 40 The results of „Total Productive Maintenance - TPM“ principle diffusion based of company’s size

In the figure above (figure 40), the result shows lean method diffusion analysis done on the “Total Productive Maintenance - TPM” principle with four categories of company’s sizes. The figure shows that large companies (LARGE) use this principle 78,6%, medium (MEDIUM) 78,5%, small (SMALL) uses 51,3% and micro (MICRO) uses only 42,4%. The highest usage of lean methods is among large size companies, which rate was almost 79%.

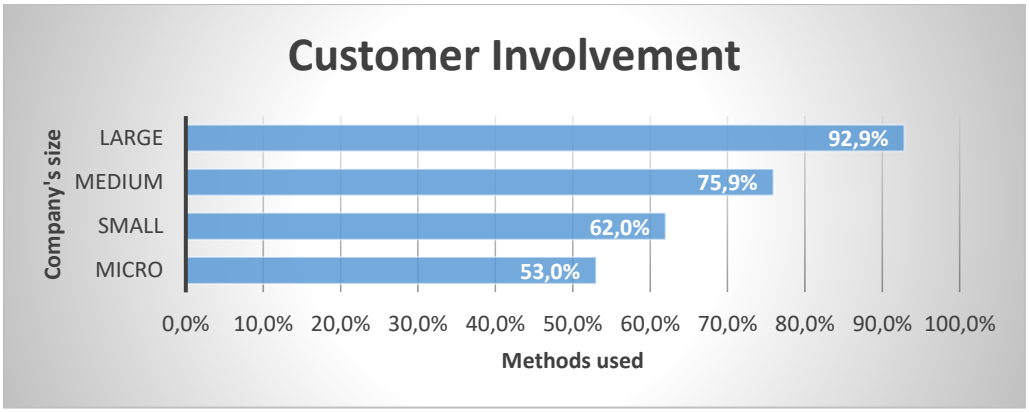

Figure 41 The results of „Customer involvement“ principle diffusion based of company’s size

In the figure above (figure 41), the result shows lean method diffusion analysis done on the “Customer Involvement” principle with four categories of company’s sizes. The figure shows that large companies (LARGE) use this principle 92,9%, medium (MEDIUM) 75,9%, small (SMALL) uses 62% and micro (MICRO) uses only 53%. The highest usage of lean methods is among large size companies, which rate was almost 92,9%.

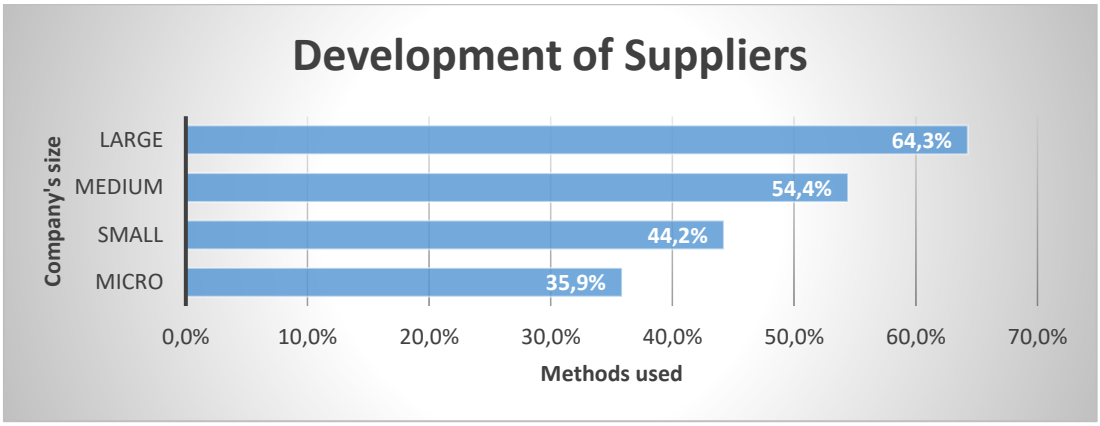

Figure 42 The results of „Development of suppliers“ principle diffusion based of company’s size

In the figure above (figure 42), the result shows lean method diffusion analysis done on the “Development of Suppliers” principle with four categories of company’s sizes. The figure shows that large companies (LARGE) use this principle 64,3%, medium (MEDIUM) 54,4%, small (SMALL) uses 44,2% and micro (MICRO) uses only 35,9%. The highest usage of lean methods is among large size companies, which rate was almost 65%.

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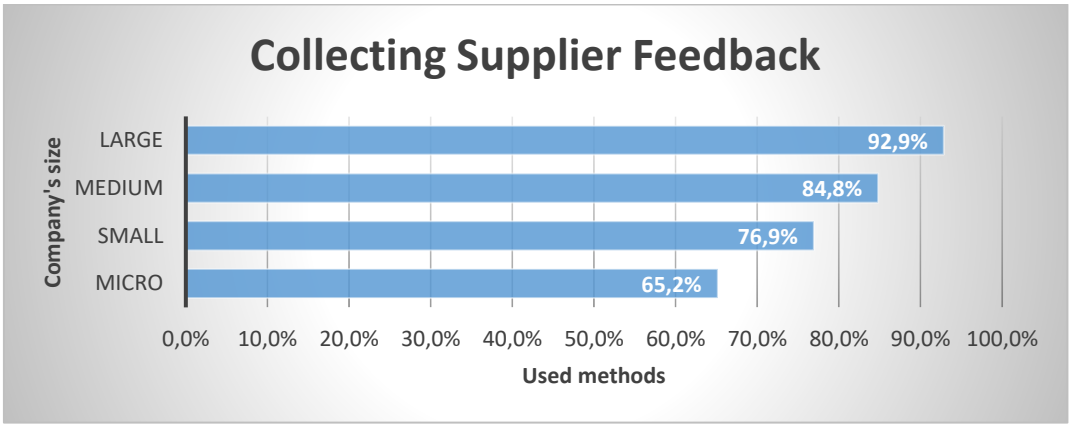

Figure 43 The results of „Collecting Supplier Feedback“ principle diffusion based of company’s size

In the figure above (figure 43), the result shows lean method diffusion analysis done on the “Collecting Supplier Feedback” principle with four categories of company’s sizes. The figure shows that large companies (LARGE) use this princilel 92,9%, medium (MEDIUM) 84,8%, small (SMALL) uses 76,9% and micro (MICRO) uses only 65,2%. The highest usage of lean methods is among large size companies, which rate was almost 93%.

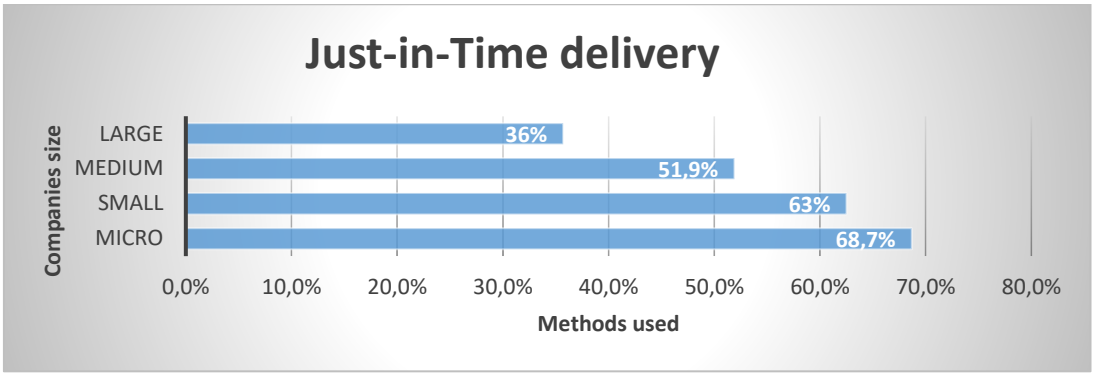

Figure 44 The results of „Just-in-Time delivery“ principle diffusion based of company's size

In the figure above (figure 44), the result shows lean method diffusion analysis done on the "Just-in-Time delivery" principle with four categories of company's sizes. The figure shows that large companies (LARGE) use this principle 36%, medium (MEDIUM) 51,9%, small (SMALL) uses 63% and micro (MICRO) uses only 68,7%. The highest usage of lean methods is among micro size companies, which rate was almost 69%. This lean method tells a different story, not like the other lean methods mentioned above.

Evaluating the results of lean methods usage based on the company's size in the figure below (figure 45) it is already clear that the usage of the lean method is more extensive depending on the company's size. It is seen how the highest rate goes to the Large sector of size and then the depending of lowering the size interval the usage rate drops. This means that the more prominent, usually more substantial companies are the ones that use lean methods more frequently than the smaller ones. It proves, that diffusion is quite significant because more prominent companies are deficient compared to smaller companies.

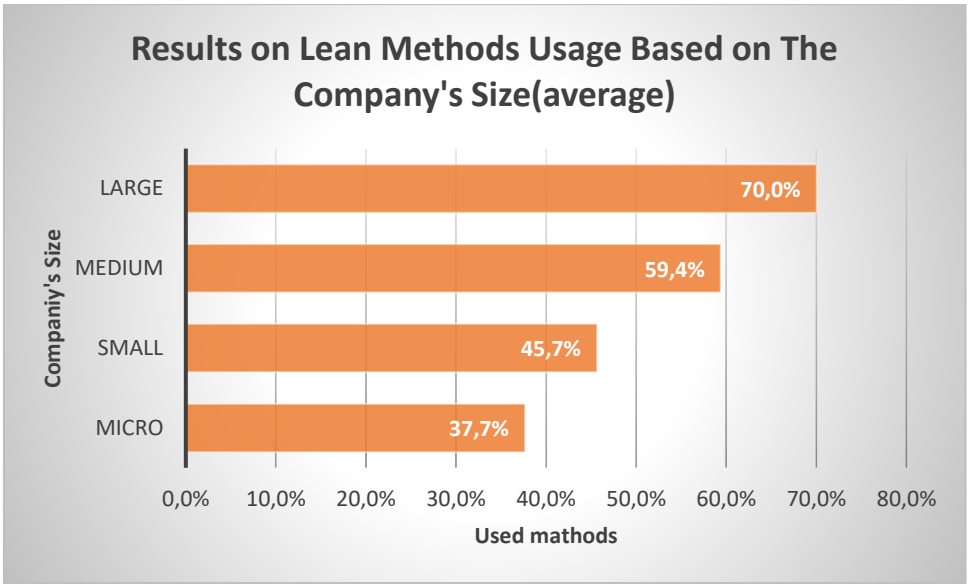

Figure 45 The results of lean methods diffususion based on companies size.

To get a better understanding of how the lean production methods are dependent on the company's size – the number of employees, the Kruskal-Wallis test will be used to see the depending on the different lean methods to the exact sizes, analyzed in this research.

Table 4. The results of Kruskal-Wallis test based of companys size (made by author)

Lean methods	P value (Asymptotic Significance)
Pull	**0,001**
Flow	**P<=0,001**
Low Setup	**P<=0,001**
SPC – Statistical Process Control	**P<=0,001**
TPM – Total Productive Maintenance	**P<=0,001**
Involvement of the Employees	**0,007**
Customer Involvement	**0,001**
Development of suppliers	**0,019**
Collecting Suppliers Feedback	**0,001**
Just-in-Time Delivery	**0,001**

As shown in the table above (table 4) the results tell that lean methods are dependent on the company's size. After taking the Kruskal-Wallis test the value p to confirm the hypothesis has to be below the 0.05 range. The test results show, that all of the lean methods are significantly lower than this rate, which means lean methods are dependent on the company's size and its impact on the diffusion of lean methods in Lithuania. This approves that the company's size is giving a substantial impact on adopting of the lean methods and the diffusion of them.

Even though the comparative analysis (figure 45) and Kruskal-Wallis test (table 4) show that all lean methods are dependent on the company's size, but the analysis done to Just-in-Time delivery lean method (figure 44) shows significantly different results from all the others. Still this method is dependant, but the diffusion results show that the smaller companies are usually willing to use this method than the companies, which have a more significant number of employees in the company.

The hypothesis is confirmed that lean production methods depend on the number of the company's number. The test results obtained from the SPSS program will be shared in the appendices section (Appendix 2). For the analysis, the sectors of Lithuania industries will be evaluated to see the result on how the industry impacts diffusion of lean methods.

4.6. The analysis of the diffusion of ` production based on indytry company is working in

This chapter will evaluate how the lean methods are diffused depending on the sectors that companies are working in. The charts are made for all ten lean methods with the six columns. The columns were made based on the companies' sector that the company is working in. The values were made the "Engineering" sector (125 working companies in this sector), "Food" sector (64 working companies in this sector), "Textiles" (70 working companies in this sector), "Wood and paper" (55 working companies in this sector), "Chemicals and chemistry" (11 working companies in this industry), "Other" (74 the companies that took part in the other sectors, that were not included). These sectors will show how lean methods are diffused among the different industry sectors.

The figures (46-55) below will show how lean methods are diffused based on the company 's sector of the industry they are doing their activities.

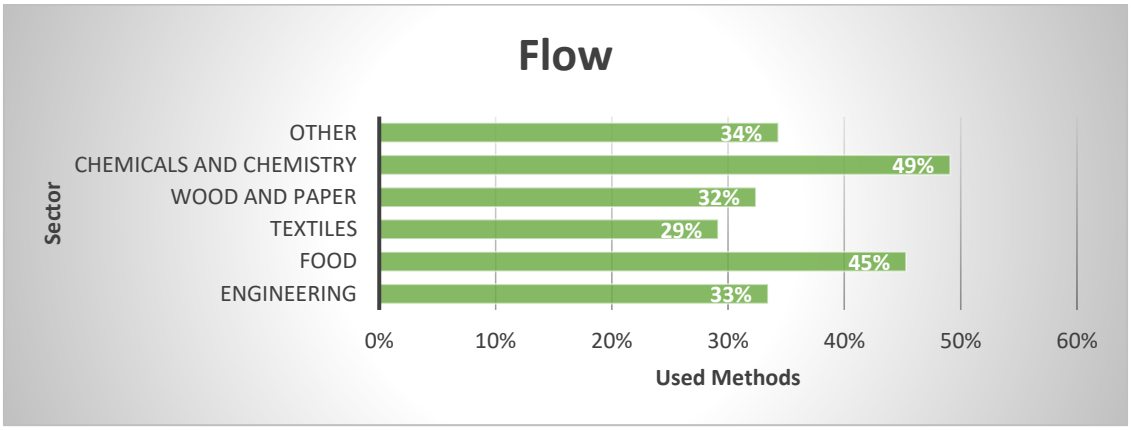

Figure 46 The results of lean method “Flow” diffusion based on the industries sector

In the figure above (figure 46), the result shows the diffusion of the lean method “Flow” depending on the industries sectors. The engineering section companies use 33%, food takes 45%, textiles use 29%, wood and paper take 32% chemicals sector used 49% based on the principle and other industries use 34%. The highest usage is chemicals industry which takes 49%.

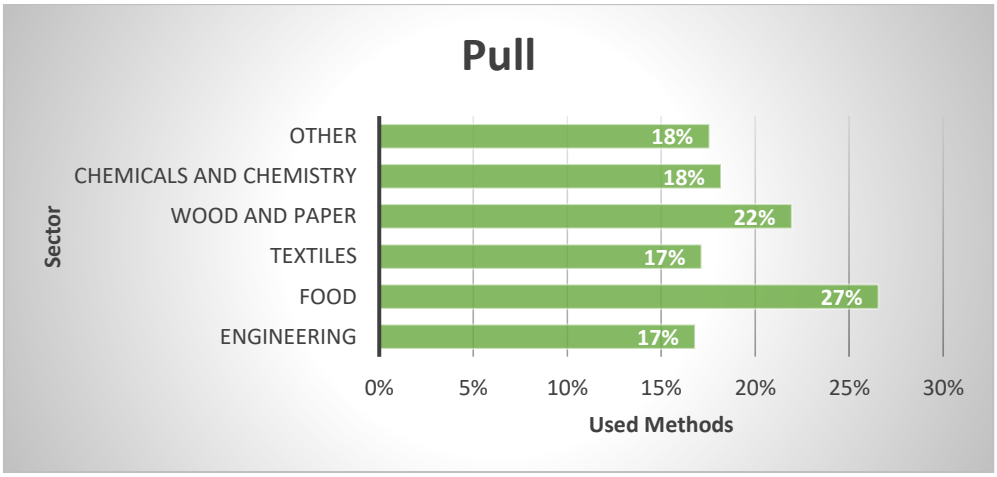

Figure 47 The results of lean method “Pull” diffusion based on the industries sector

In the figure above (figure 47), the result shows the diffusion of the lean method “Pull” depending on the industries sectors. The engineering section companies use 17%, food takes 27%, textiles use 17%, wood and paper take 22% chemicals sector used 18% based on the principle and other industries use 18%. The highest usage is food industry which takes 27%.

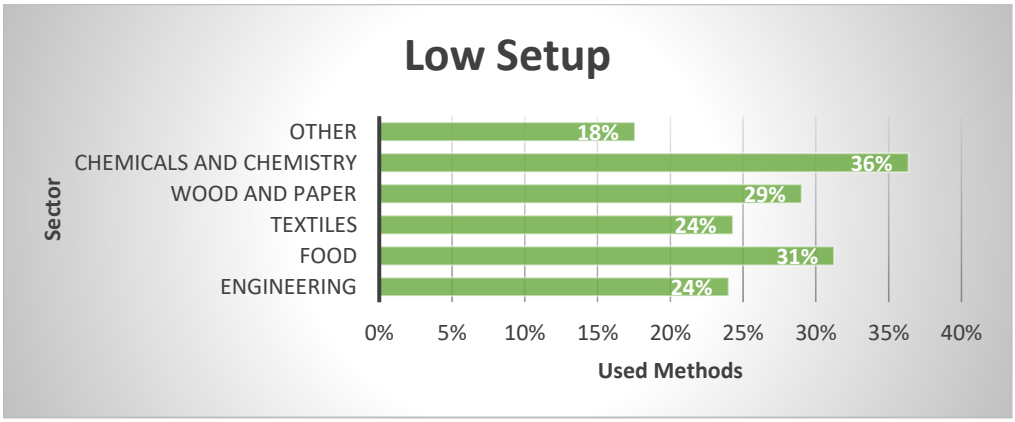

Figure 48 The results of lean method “Low setup” diffusion based on the industries sector

In the figure above (figure 48), the result shows the diffusion of the lean method “Low Setup” depending on the industries sectors. The engineering section companies use 24%, food takes 31%, textiles use 24%, wood and paper take 29% chemicals sector used 36% based on the principle and other industries use 18%. The highest usage is chemicals industry which takes 36%.

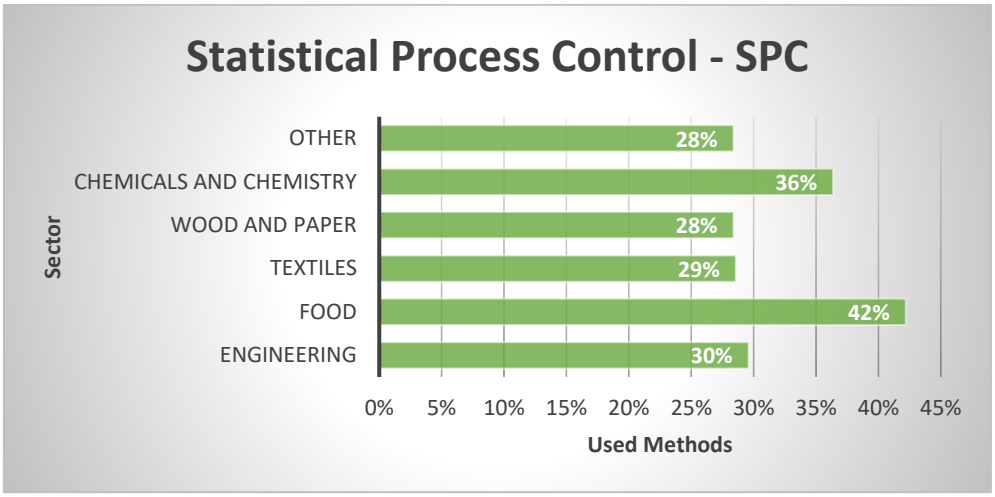

Figure 49 The results of lean method “Statistical Process Control - SPC” diffusion based on the industries sector

In the figure above (figure 49), the result shows the diffusion of the lean method “Statistical Process Control - SPC” depending on the industries sectors. The engineering section companies use 30%, food takes 42%, textiles use 29%, wood and paper take 28% chemicals sector used 36% based on the principle and other industries use 28%. The highest usage is food industry which takes 42%.

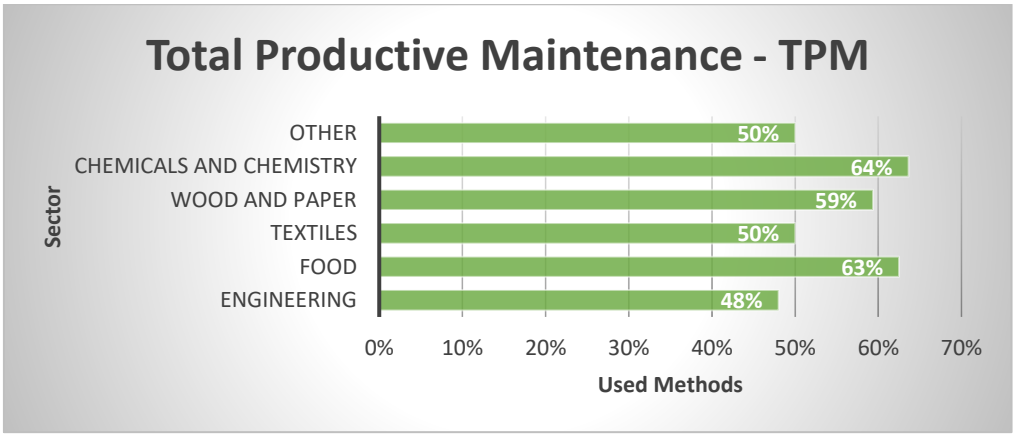

Figure 50 The results of lean method "Total Productive Maintenance - TPM" diffusion based on the industries sector

In the figure above (figure 50), the result shows the diffusion of the lean method "Total Productive Maintenance - TPM" depending on the industries sectors. The engineering section companies use 48%, food takes 63%, textiles use 50%, wood and paper take 59% chemicals sector used 64% based on the principle and other industries use 50%. The highest usage is cgemicals industry which takes 64%.

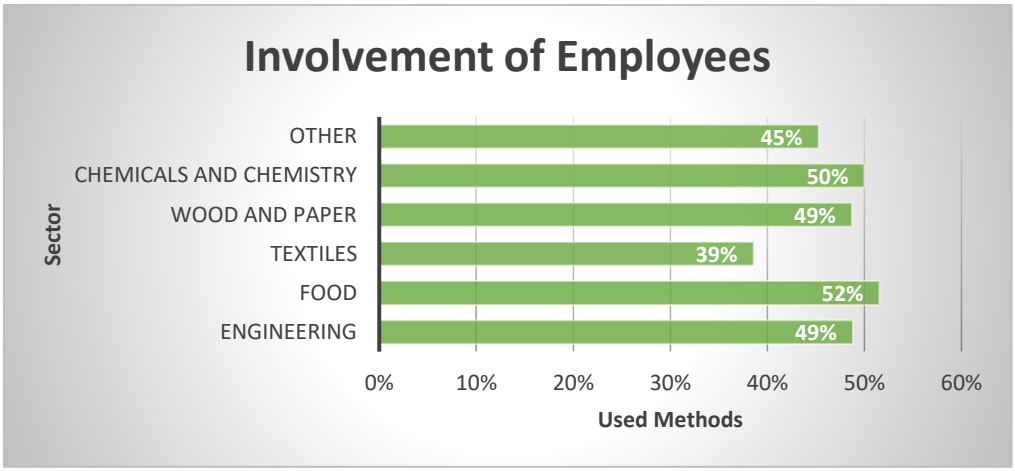

Figure 51 The results of lean method "Involvement of Employees" diffusion based on the industries sector

In the figure above (figure 51), the result shows the diffusion of the lean method "Involvement of Employees" depending on the industries sectors. The engineering section companies use 49%, food takes 52%, textiles use 39%, wood and paper take 49% chemicals sector used 50% based on the principle and other industries use 45%. The highest usage is food industry which takes 52%.

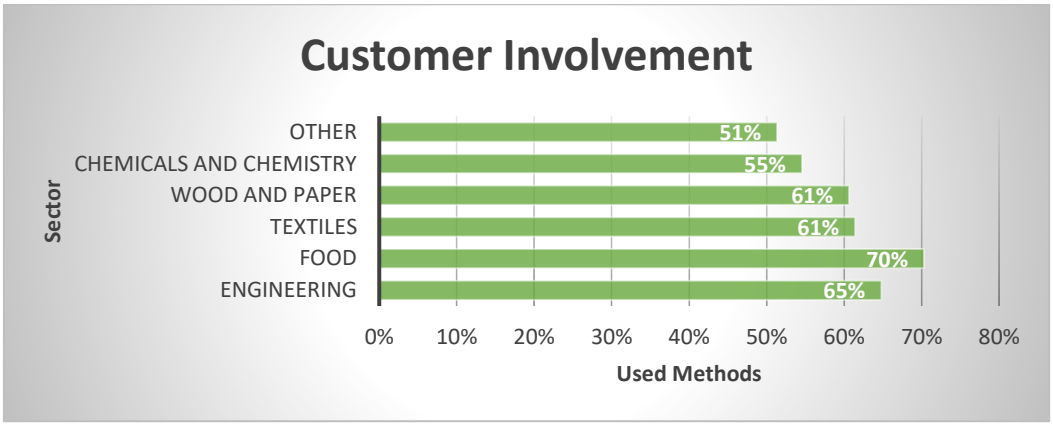

Figure 52 The results of lean method "Customer involvement" diffusion based on the industries sector

In the figure above (figure 52), the result shows the diffusion of the lean method "Customer Involvement" depending on the industries sectors. The engineering section companies use 65%, food takes 70%, textiles use 61%, wood and paper take 61% chemicals sector used 55% based on the principle and other industries use 51%. The highest usage is food industry which takes 70%.

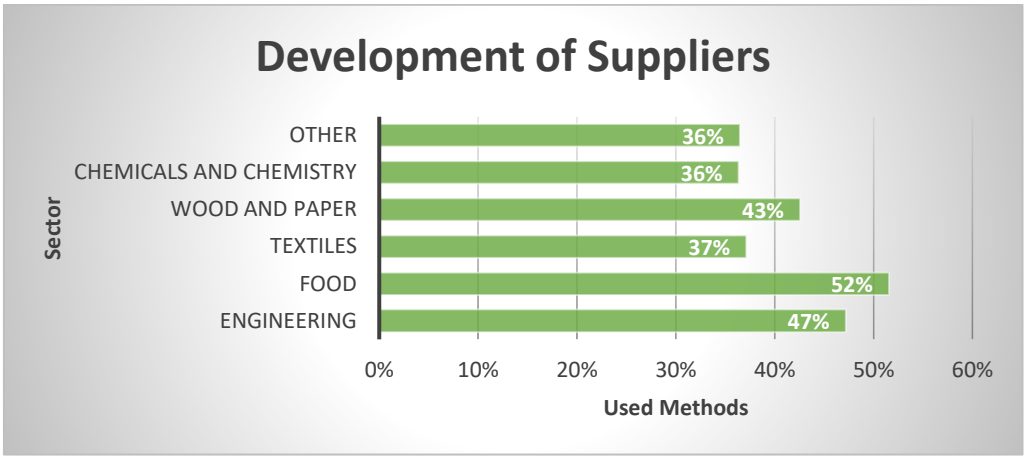

Figure 53 The results of lean method "Development of suppliers" diffusion based on the industries sector

In the figure above (figure 53), the result shows the diffusion of the lean method "Development of Suppliers" depending on the industries sectors. The engineering section companies use 47%, food takes 52%, textiles use 37%, wood and paper take 43% chemicals sector used 36% based on the principle and other industries use 36%. The highest usage is food industry which takes 52%.

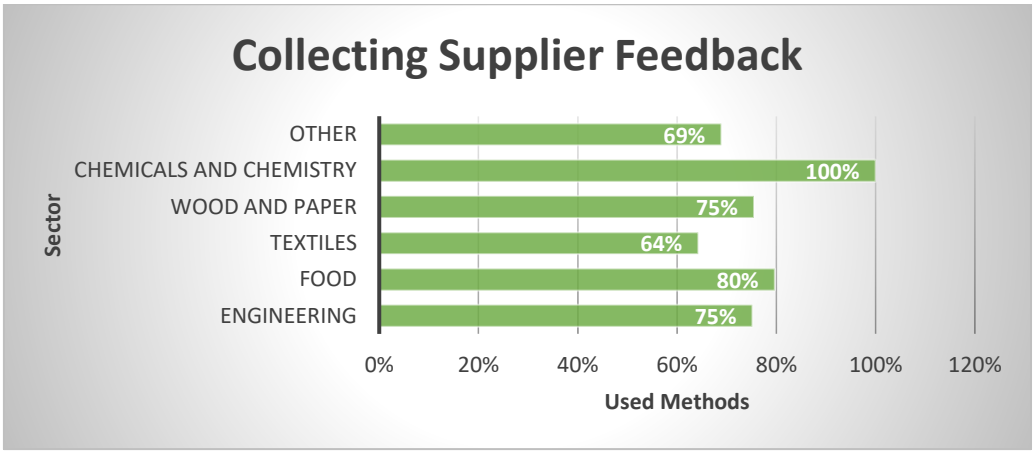

Figure 54 The results of lean method "Collecting Supplier Feedback" diffusion based on the industries sector

In the figure above (figure 54), the result shows the diffusion of the lean method "Collecting Supplier Feedback" depending on the industries sectors. The engineering section companies use 75%, food takes 80%, textiles use 64%, wood and paper take 75% chemicals sector used 100% based on the principle and other industries use 69%. The highest usage is chemicals industry which takes 100%.

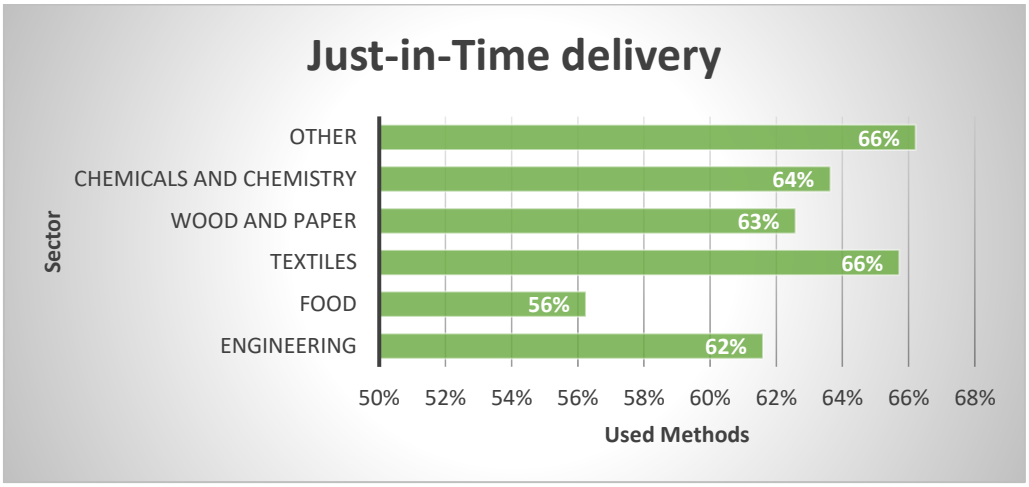

Figure 55 The results of lean method "Just-in-Time delivery" diffusion based on the industries sector

In the figure above (figure 55), the result shows the diffusion of the lean method "Just-in-Time delivery" depending on the industries sectors. The engineering section companies use 62%, food takes 56%, textiles use 66%, wood and paper take 63% chemicals sector used 64% based on the principle and other industries use 66%. The highest usage is textiles industry which takes 66%.

After making a final result of all the lean methods usage in different production industry sectors (figure 56), the figure shows no significant difference in lean production usage based on the sector. From the figure, food and chemical industries are above 50% all other sectors do pas the 40% of usage but there is no significant difference based on the number of companies working in the specific sector and lean methods they are using. To figure out why these outcomes are so similar, consider the following: the Kruskal-Wallis test will be done.

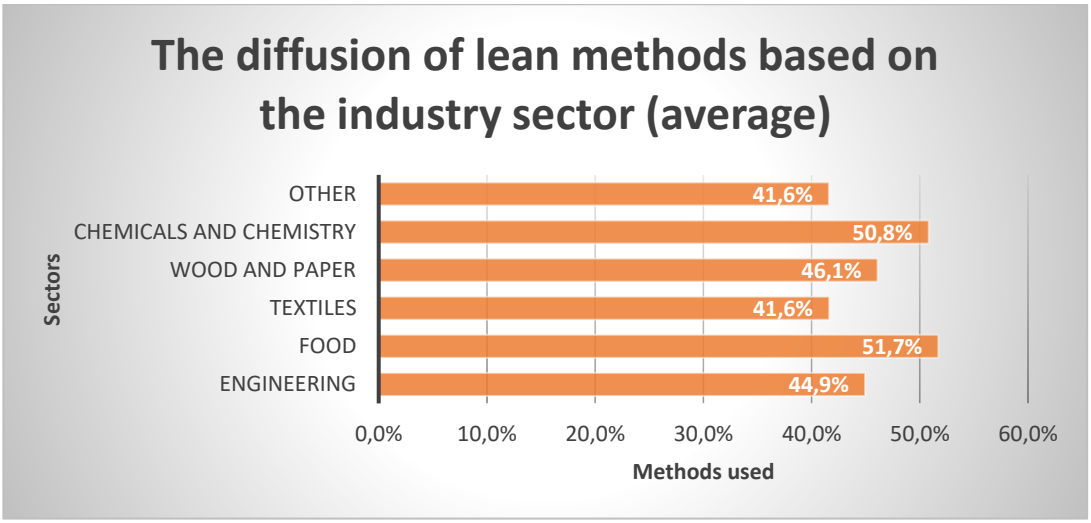

Figure 56 The results of lean methods diffusion based on industry sector

To see if lean procedures are reliant on the sector of producing enterprises., the Kruskal Wallis test is done. This will show if the hypothesis is confirmed or denied because looking from the comparative method used in the figure 56, the lean methods do not show any depending on the company's sectors.

Table 5. The results of Kruskal Wallis test based on companies sector (made by author).

Lean method	**p value (Asymptotic Significance)**
Pull	0,616
Flow	0,194
Low Setup	0,373
SPC – Statistical Process Control	0,425
TPM – Total Productive Maintenance	0,238
Involvement of Employees	0,359
Customer Involvement	0,292
Development of Suppliers	0,384
Collecting Supplier Feedback	0,087
Just-in-Time Delivery	0,868

From the comparing analysis (figure 56), lean methods do not impact the sector to the usage and diffusion of the methods. To confirm the hypothesis that lean methods diffusion is uneven based on the company's sector Kruskal Wallis test was used to determine whether the lean methods are dependent on the companies sector.

The p-value had to be less than the 0,05 factor to determine if the lean approaches are dependant. The results are shown in the table above (table 5) show thatthe Asymptotic Significance value (p-value) of all the lean production methods analyzed in this research gave a higher rate, which means that these lean methods have no commonality with the company's sectors. The lowest value was gotten by "Collecting Supplier Feedback" which is also too high to determine that it is dependant.

All in all, it is clear to say that the hypothesis that lean methods are diffused unevenly because of different production industries sectors has to be rejected because none of the lean methods had an appropriate p-value, to satisfy the hypothesis.

CONCLUSION AND RECOMMENDATION

1.From the literature analysis and the research done on different articles, it was found out that the concept lean was firstly used in the automotive industry; the pioneer was Toyota systems. Further on the lean concept was adopted by manufacturing or producing companies that usually think about specific production solutions. The lean concept stater looks very appealing to the companies, because it helps organizations develop strategies. The strategies do combine from rearranging the manufacturing flows, improving efficiency, lowing the manufacturing process cycles, helping companies to produce better quality products in a shorter period, with using the maximum amount of the waste and by doing that reducing the manufacturing cost which would be more appealing for the customers and the companies' organizations are working with. According to the research, lean methods and policies help companies become more competitive than the companies that are not using them. This is how the model was made, which represents how the specific factors influence lean methods diffusion.

2.From the theoretical analysis, it was found that all lean production methods have a positive impact on the company's everyday tasks. The production methods are related to each other, from the standardized work to fluent manufacturing flow to the accuracy of the company, suppliers, and customers. In this research, the lean production methods were separated into three different groups based on their specifications: internally-related, customer-related, and supplier-related methods. All of the groups gave different impacts on the companies, including different tasks and procedures, but are all dependent on each other. Evaluating the uneven diffusion of lean methods in the Lithuania companies has helped develop the most vital factors that stimulate companies to innovate and grow in continuous improvements towards getting better results. The factors were found that company size helps companies take innovative ideas and adapt them quickly because of the solid financial support. The second factor was concluded as the exporting activity. By exporting, companies usually work with technologically more substantial companies and pressure the companies if they want to continue the cooperation. The last of the factors were outlined as the sector of the industry. It is already known that companies with more significant competition in the same production field tend to search for innovations and ideas to become more competitive in the industry. To sum up the factors were outlined to be evaluated towards the research to know if the lean methods are diffused.

3.The conceptual model was created for all the lean methods based on the three factors included in the theoretical part: company size, export, industry sector. The evaluation began with the systematized survey data to moderate the data file to the research problem thematic. The comparing method with the help of the model created will help see the preliminary results how the factors affect the diffusion of lean methods in Lithuanian companies. From the start, the geographical analysis was done to understand the companies' content that participated in the survey. Next, the currently used methods were made by the frequency analysis to determine the current usage of lean methods in general of the Lithuanian companies. Extenting potential was also evaluated to know how companies evaluated each of the lean production methods to know which gives the company's most significant value and which ones are the least giving value for the company's tasks. From the analyzed collected data, the three factors mentioned before were evaluated based on the lean production methods analyzed based on Shah and Ward (2007). The comparing analysis showed which factors impact on lean methods diffusion and which ones do not give any significant difference.

4.The empirical research data helped to evaluate the tasks that were defined before. Form the currently used methods in Lithuania results of the 500 valid respondents, which some of them did not answer the question; they were not involved in the final results. The results show that 70% of the lean methods are used frequently; the results showed that they are above 45% of usage, some of the methods reached 80% that are currently used. This means that Lithuanian companies are familiar with this concept. The extent of used potential results showed a little different story than the currently used methods. The most popular used method (79% currently used) did not give the most significant value (2,3 out of 3) for the companies, and the least used methods (23,1% currently used) were not in the last place as an added value for the company (1,98 out of 3, the lowest value 1,82). This showed that the more extensive usage does not mean to show the most considerable value they are adding. The comparing method was used to see whether exporting companies are using lean methods more than non-exporting companies. The results showed that almost all of the methods are used when the company is doing exporting activities, the rate of the methods that are dependent on export showed that was 70-80%, which means lean methods are related to export and impact the diffusion of lean methods. The next was companies' size; this factor also approved those lean methods are dependant on this factor because all of the lean methods asymptotic significance value was below 0,05, which mean all the methods approved the hypothesis that the diffusion of lean methods is dependent on the size of the organization. The last factor analyzed was the company's industrial sector; the hypothesis was made that the production companies have a significant difference in lean methods usage based on their sector. This hypothesis was rejected because after doing the Kruskal Wallis test, all the p-values were above the rate of 0,05; this means all the lean production methods are independent of the company's sector. All in all, the lean methods diffusion is made from two factors that were evaluated in this research-export and organization size. This could help companies understand how to break the barriers of implementing lean methods and minimize diffusion.

RECOMMENDADIONS

- From the literature review, it was found that lean methods give sihnificant adding value for the companies and help them to become competitive in the market, but the diffusion growth of lean methods because not all companies give attention to the factors that help companies to use lean production methods.
- The analyzed data and gain results show that 70-80% of lean methods are dependant on export, 90-100% dependent on the company's size and significantly independent from the sector the company works and produces the products. Which mean size and export factors make an impact on the diffusion of lean production methods.
- From the frequency analysis currently, used methods results did show the unevenness of lean production methods because the lowest used method reached 23,1% rate of usage and the highest used method reached 79%. This means the diffusion of lean methods is very uneven because some methods are not admitted by the companies or are not available based on work strategies.

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APPENDICES

1 Appendix. Table 3 explanation.

Standardized and detailed work instructions

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4,446[a]	1	,035		
Continuity Correction[b]	4,033	1	,045		
Likelihood Ratio	4,393	1	,036		
Fisher's Exact Test				,045	,023
Linear-by-Linear Association	4,438	1	,035		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 56,49.

b. Computed only for a 2x2 table

Measures to imrpove internal logistics

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10,759[a]	1	,001		
Continuity Correction[b]	10,050	1	,002		
Likelihood Ratio	11,381	1	,001		
Fisher's Exact Test				,001	,001
Linear-by-Linear Association	10,738	1	,001		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 40,91.

b. Computed only for a 2x2 table

Fixed process flows to reduce setup time or optimize change-over time

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	13,586[a]	1	,000		
Continuity Correction[b]	12,793	1	,000		
Likelihood Ratio	14,476	1	,000		
Fisher's Exact Test				,000	,000
Linear-by-Linear Association	13,559	1	,000		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 41,88.

b. Computed only for a 2x2 table

Production controlling following the Pull principle

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11,492[a]	1	,001		
Continuity Correction[b]	10,693	1	,001		
Likelihood Ratio	12,450	1	,000		
Fisher's Exact Test				,001	,000
Linear-by-Linear Association	11,468	1	,001		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 32,14.

b. Computed only for a 2x2 table

Organization of production by u-lines

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2,704[a]	1	,100		
Continuity Correction[b]	2,347	1	,126		
Likelihood Ratio	2,776	1	,096		
Fisher's Exact Test				,115	,061
Linear-by-Linear Association	2,699	1	,100		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 38,31.

b. Computed only for a 2x2 table

Regulation of placement and maintenance of work tools and intermediate products

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1,472[a]	1	,225		
Continuity Correction[b]	1,227	1	,268		
Likelihood Ratio	1,493	1	,222		
Fisher's Exact Test				,247	,134
Linear-by-Linear Association	1,469	1	,226		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 46,75.

b. Computed only for a 2x2 table

Decreasing the time of equipment downtime

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9,406[a]	1	,002		
Continuity Correction[b]	8,827	1	,003		
Likelihood Ratio	9,397	1	,002		
Fisher's Exact Test				,003	,001
Linear-by-Linear Association	9,387	1	,002		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 74,02.

b. Computed only for a 2x2 table

Statistical methods which are intended fo manafement of production and control processes

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9,254[a]	1	,002		
Continuity Correction[b]	8,634	1	,003		
Likelihood Ratio	9,607	1	,002		
Fisher's Exact Test				,003	,001
Linear-by-Linear Association	9,235	1	,002		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 49,67.

b. Computed only for a 2x2 table

Display boards in production to illustrate work processes and work status

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9,921[a]	1	,002		
Continuity Correction[b]	9,273	1	,002		
Likelihood Ratio	10,341	1	,001		
Fisher's Exact Test				,002	,001
Linear-by-Linear Association	9,901	1	,002		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 48,05.

b. Computed only for a 2x2 table

Involvement of employees into improvements

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,009[a]	1	,923		
Continuity Correction[b]	,000	1	1,000		
Likelihood Ratio	,009	1	,923		
Fisher's Exact Test				1,000	,501
Linear-by-Linear Association	,009	1	,923		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 68,50.

b. Computed only for a 2x2 table

Integration of tasks

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	16,396[a]	1	,000		
Continuity Correction[b]	15,603	1	,000		
Likelihood Ratio	17,023	1	,000		
Fisher's Exact Test				,000	,000
Linear-by-Linear Association	16,363	1	,000		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 59,41.

b. Computed only for a 2x2 table

Involvement of customers into production

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9,478[a]	1	,002		
Continuity Correction[b]	8,883	1	,003		
Likelihood Ratio	9,377	1	,002		
Fisher's Exact Test				,002	,002
Linear-by-Linear Association	9,459	1	,002		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 62,33.

b. Computed only for a 2x2 table

Development of suppliers

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4,347[a]	1	,037		
Continuity Correction[b]	3,954	1	,047		
Likelihood Ratio	4,387	1	,036		
Fisher's Exact Test				,043	,023
Linear-by-Linear Association	4,339	1	,037		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 69,80.

b. Computed only for a 2x2 table

Collecting supplier feedback

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7,768[a]	1	,005		
Continuity Correction[b]	7,173	1	,007		
Likelihood Ratio	7,565	1	,006		
Fisher's Exact Test				,006	,004
Linear-by-Linear Association	7,752	1	,005		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 42,20.

b. Computed only for a 2x2 table

Just-in-Time delivery

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2,318[a]	1	,128		
Continuity Correction[b]	2,028	1	,154		
Likelihood Ratio	2,343	1	,126		
Fisher's Exact Test				,139	,077
Linear-by-Linear Association	2,314	1	,128		
N of Valid Cases	499				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 60,71.

b. Computed only for a 2x2 table

2 Appendix , table 4 explanation

Test Statistics[a,b]

	Currently used. Standardized and detailed work instructions	Currently used. Measures to improve internal logistics	Currently used. Fixed process flows to reduce setup time or optimize change-over time	Currently used. Production controlling following the Pull principle	Currently used. Organization of production by u-lines	Currently used. Regulation of placement and maintenance of work tools and intermediate products	Currently used. Decreasing the time of equipment downtime	Currently used. Statistical methods which are intended for the management of production and control processes	Currently used. Display boards in production to illustrate work processes and work status	Currently used. Involvement of employees into improvement	Currently used. Integration of tasks	Currently used. Involvement of customers into production	Currently used. Development of suppliers	Currently used. Collecting supplier feedback
Kruskal-Wallis H	26,155	50,052	27,532	15,599	39,027	28,921	33,220	73,075	31,671	10,755	53,011	16,788	9,974	16,351
df	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Asymp. Sig.	,000	,000	,000	,001	,000	,000	,000	,000	,000	,013	,000	,001	,019	,001

a. Kruskal Wallis Test

b. Grouping Variable: 2017 Number of employees

Currently used. Just-in-time delivery
15,845
3
,001

3 Appendix , table 5 explanation

Test Statistics[a,b]

	Currently used. Standardized and detailed work instructions	Currently used. Measures to improve internal logistics	Currently used. Fixed process flows to reduce setup time or optimize change-over time	Currently used. Production controlling following the Pull principle	Currently used. Organization of production by u-lines	Currently used. Regulation of placement and maintenance of work tools and intermediate products	Currently used. Decreasing the time of equipment downtime	Currently used. Statistical methods which are intended for the management of production and control processes	Currently used. Display boards in production to illustrate work processes and work status	Currently used. Involvement of employees into improvement	Currently used. Integration of tasks	Currently used. Involvement of customers into production	Currently used. Development of suppliers	Currently used. Collecting supplier feedback
Kruskal-Wallis H	8,384	13,786	5,377	3,545	7,859	14,326	6,775	4,926	3,405	3,083	12,177	6,155	5,269	9,606
df	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Asymp. Sig.	,136	,017	,372	,617	,164	,014	,238	,425	,638	,687	,032	,291	,384	,087

a. Kruskal Wallis Test

b. Grouping Variable: Industry sector code

Currently used. Just-in-time delivery
1,858
5
,868