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Development of a hybrid framework for new product development using Stage-gate process and Lean Startup methodology.

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Esta dissertação foi julgada adequada para a obtenção do título de mestre em Engenharia e Ciências Mecânicas e aprovada em sua forma final pelo Programa de Pós-graduação em Engenharia e Ciências Mecânicas da Universidade Federal de Santa Catarina.

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ABSTRACT

Companies are pursuing to implement their strategies through the execution of projects in several areas of the organization, such as Research and Development, Manufacturing, Quality, Environment and Safety. The product development involves the application of methods, techniques and tools, which according to the new product development process should occur in stages and gates. As the economic notoriety changes to developing markets, global companies need new ways to implement their strategies. Recently, the use of the Lean Startup approach has grown rapidly in established companies aim to reach a radical innovation. Although the attempt of several authors to investigate how Lean startup facilitates product innovation in existing companies, it was observed that there is an opportunity to propose the application of the Lean Startup methodologies into the traditional stage-gate process. This dissertation presents a literature review in strategy, digital innovation, Lean Startup and Stage-Gate. The framework developed for this study enables to establish the research questions. Each of the research questions aimed at covering a specific aspect of the area under investigation. The research method was the self-administrated questionnaire. Total of 127 respondents answered and the results show that digital strategy and innovation are driving new product development and creating new business models. This study found the more often activities of Stage-gate process (e.g., market viability and risk assessment) and Lean Startup method (e.g. set the main hypothesis for product and business, build minimum viable product, define engine of growth and validated learning). Also, the results show the Stage-gate and Lean Startup can be used in any size of project, type of product (physical or software) and type of innovation (incremental or radical). As a contribution to this research field, it was developed and evaluated the hybrid product development framework. In conclusion, the study suggests some modifications in the Stage-gate process adding activities, tools and features from Lean Startup to enrich the new product development area.

Key Words: Strategy, Digital innovation, Stage-Gate, Lean Startup, Hybrid framework

RESUMO

As empresas estão buscando implementar suas estratégias através da execução de projetos em diversas áreas da organização, como Pesquisa e Desenvolvimento, Manufatura, Qualidade, Meio Ambiente e Segurança. O desenvolvimento de produtos envolve a aplicação de métodos, técnicas e ferramentas que, de acordo com o processo de desenvolvimento de novos produtos, devem ocorrer em etapas e portões. À medida que a notoriedade econômica muda para os mercados em desenvolvimento, as empresas globais precisam de novas formas de implementar suas estratégias. Recentemente, o uso da abordagem Lean Startup cresceu rapidamente em empresas estabelecidas com o objetivo de alcançar uma inovação radical. Embora a tentativa de vários autores em investigar como a inicialização Lean facilita a inovação de produtos em empresas existentes, observou-se que há uma oportunidade de propor a aplicação das metodologias Lean Startup no tradicional processo de estágio. Esta dissertação apresenta uma revisão da literatura em estratégia, inovação digital, Lean Startup e Stage-Gate. A estrutura desenvolvida para este estudo permite estabelecer as questões de pesquisa. Cada uma das questões de pesquisa visava cobrir um aspecto específico da área sob investigação. O método de pesquisa foi o questionário auto administrado. Um total de 127 respondentes respondeu e os resultados mostram que a estratégia digital e a inovação estão impulsionando o desenvolvimento de novos produtos e criando novos modelos de negócios. Este estudo encontrou as atividades mais frequentemente do processo Stage-gate (por exemplo, viabilidade de mercado e avaliação de risco) e método Lean Startup (por exemplo, definir a hipótese principal para produto e negócio, construir produto viável mínimo, definir motor de crescimento e aprendizagem validada). Além disso, os resultados mostram que o Stage-gate e o Lean Startup podem ser usados em qualquer tamanho de projeto, tipo de produto (físico ou software) e tipo de inovação (incremental ou radical). Como contribuição para este campo de pesquisa, foi desenvolvido e avaliado o framework de desenvolvimento de produtos híbridos. Para concluir, o estudo sugere algumas modificações no processo Stage-gate, adicionando atividades, ferramentas e recursos do Lean Startup para enriquecer a área de desenvolvimento de novos produtos.

Palavras-chave: Estratégia, inovação digital, Stage-Gate, Lean Startup, Hibrido framework

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LIST OF ABBREVIATIONS

BML – Build Measure Learn
FAPESC – Fundação de Amparo à Pesquisa e Inovação do Estado de Santa Catarina
GE – General Electric
HR – Human Resources
IoT – Internet of Things
KPIs – Key Process Indicators
LS – Lean Startup
MVP – Minimum Viable Product
NPP – Net Present Value
NPD – New Process Development
OEM – Original Equipment Manufacturer
PDCA – Plan Do Check Action
PDMA – Product Development and Management Association
R&D – Resources and Development
ROI – Return on Investment
SRL – Systematic Literature Review
VoC – Voice of Customer

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1 INTRODUCTION

This chapter begins with a scenario of strategy, innovation, traditional new product development, Stage-gate, and Lean Startup as the context of the study. Also, it contains the statement of the problem, the significance of this study for the new product development area, the description of the objectives and an explanation of the dissertation structure.

1.1 SCENARIO

The strategy is a complex and dynamic business area. A strategy is a necessary and unstable definition for the future because it depends on market forces and changes that are outside of companies control. Great companies are always adapting, and that means changing strategy frequently to meet with their needs. While it is fundamental to develop an initial, overall strategy for the company, it is improbable that this strategy is going to support the company for very long.

The importance of innovation in companies is unquestionable. The tendency in recent years has demonstrated that the rising numbers of small, innovation-driven start-up companies are building the future of business. Managers in established companies are challenged to launching new innovative products, find new sources of growth or new markets (COOPER, 2011; RIES, 2011). Digital technologies are changing business in the last decade (MCKINSEY&COMPANY, 2018). Several Startups have changed traditional industries and business such as eBay, Dropbox, Über and Airbnb. Companies should respond to this change and fast innovate (RINGEL et al., 2018; VIKI, 2017).

Most companies in the 21st century focus on growing their capacity, product quality, competition cost, fast delivery and flexibility. New products usually correspond to incremental innovation in their existing products. They aim to growth by advertising to reach new customers with a current product (RIES, 2011, p.23).

New products can be developed and produce any place in the world with low costs, and customers can quickly find out them. Incremental improvements to current products or small variations thereof are relatively predictable investments, as are process improvement to increase quality and margins. The traditional new product development process (NPD) is suitable for this kind of innovation (RIES, 2011).

However, some parts of the product portfolio, where companies need radical innovation, the traditional product development process tools do not work correctly. Then, companies need new sources of growth that can only come from innovation. Most companies do not have anything to replace their traditional process. For continuous innovation, established companies need to choose the right methods and tools to create new products and business model. Essential elements in the innovation field are skills which help to identify market opportunities, create conditions for developing innovative solutions and the ability to update the innovation processes (RIES, 2011).

The industry keeps changing faster and reinventing all its secrets, methods, techniques and channels, resulting in new products platforms. Indeed, the large companies are not waiting for these new platforms to appear. Instead, they are creating engineers groups to support the company to innovate new platforms as required (HASHMI, 2016).

There are many examples of companies adding new business models to their portfolio management. For example, Amazon developed tablets, the Echo, the Alexa voice-activated assistant, food delivery, original television, and its own line of baby products. Amazon has quite a lot of different new businesses (RIES, 2011).

Considering that each project is unique and contain different levels of innovations, it is possible to understand that to innovate is necessary to address the uncertainty of the market and technology inherent to the project. Most companies use the traditional new product development linear model (COOPER, 1994) because their projects are incremental innovation, but, there are also many radical innovation projects cannot work with the traditional model (SERGIO et al., 2015).

Most companies manage innovation through the traditional waterfall or stage gates process methodologies. The managers or the teams choose one idea and prepare a complete business case before the investment. If they get the approval of the budget, then the teams establish a product roadmap and spend months in product development involving different department of their company. Next, they will launch the product and marketing will start contact with customers (VIKI, 2017).

During many years to write a robust business plan was considered the best decision to be aimed to reach the project success. This traditional business plan contains detailed information related to products, services, marketing plan, operational plan, and financial plan. All this information requires the understanding of product and business, what can be suitable for large companies that have wide knowledge of their

products and markets (RASMUSSEN, E. S., TANEV, 2016; RIES, 2011).

Moreover, the traditional business plan contains uncertain predictions for Return on Investment (ROI) and Net Present Value (NPP) (VIKI, 2017). According to BLANK (2013), a business plan certainly does not survive after the first contact with the customers because it is written before the company has started to create a product and collect feedback from customers.

Additionally, the business plan cannot help to predict anything for a new product (based on radical innovation) and new market. There is no information available. All this knowledge has to be learned with the new customers (RASMUSSEN, E. S., TANEV, 2016; RIES, 2011).

In this traditional management process dedicate a lot of effort on planning. The entrepreneurs need some management skills and use the most effective methods to develop new products and services. The product development process is recognized as a discipline that increases the efficiency of the implementation of projects.

Companies need to update the way they define their priority to approve or reject one riskiest project. They need rather than focus new product development on ROI, traditional accounting, and market share; they should track the progress of the project, project teams as metrics that they can show the truth (RIES, 2017).

The entrepreneurs from Startup are pursuing for a feasible business model that help them to address the customer needs, finding the correct product result through testing and learning about the product and business hypotheses rather than starting the execution a whole plan that may have misleading hypotheses, and may limit innovation (RASMUSSEN, E. S., TANEV, 2016).

The Lean Startup method was designed for radical innovation, where high risks of the new products, new technologies, and uncertainty markets are involved. The new business in small or large companies can apply this method to test and validate the new ideas through customers feedback (BLANK, 2013; RASMUSSEN, E. S., TANEV, 2016; RIES, 2011).

Established companies fail to innovate when they use the same traditional product development processes. They should use Lean Startup methods that include experiments and iterations with customers instead of Stage-gate process. And, they should incrementally invest when each innovation stage is completed, and new information is available (VIKI, 2017).

Some managers do not recognize the size of the challenge to implement Lean Startup into the companies, and they frequently concentrate on training the teams how to run experiments, build minimum viable products and design innovative business models, and they forget the rest. There is no change in their strategy, product portfolio approach, investment process and organizational culture (VIKI, 2017).

The problem is that when these teams return to their work, they are still part of a company that uses traditional methods to manage innovation. Also, a lot of companies failing to connect Lean Startup to key business outcomes. These companies need a methodology to respond to disruption, and changes in how they nurture innovation and growth. Lean Startup is one of the modern management approaches that companies should use (VIKI, 2017).

Traditional product development has decision gates at the end of main stages (i.e., idea generation, preliminary investigation, detailed investigation, development, testing/validation, product launch and review) (COOPER, 1994, 2018). However, the Lean Startup method suggests they can also need to add some validated learning gates at the end of each sub-stage (e.g., test ideas: problem exploration, solution validation, business model) (VIKI, 2017).

Also, the company should have some governance key process indicators (KPIs) to help during investment decisions, such as measure if the teams are close to discovery new product to market. A company should measure project progress and make incremental investments depend on its phase. This way allows a company to learn whether the product idea has potential before they make bigger investments (RIES, 2011, 2017; VIKI, 2017).

Companies need to establish the global KPIs to measure the overall performance of their investments, for example, percent of revenue in the last three years (RIES, 2011, 2017; VIKI, 2017).

Within a context that digital has transformed the world in the last decades (ANDREESSEN, 2011; GIEREJ, 2017; RINGEL et al., 2018), innovating is a fundamental activity that demands new method and tools such as Lean Startup method (BLANK, 2013; RIES, 2011, 2017). The Stage-gate process is worldwide known and used since decade 60 (COOPER, 1994, 2018; SERGIO et al., 2015). The theoretical and practical relationship between these methods and tools is worth investigating and should specifically examine how established companies could add Lean Startups practices in their product development process.

Innovation has two different definitions: (i) innovation to modify and adapt their products and services to changing internal and/ or market

conditions and frequently refers to the process New Product Development (NPD) (SERGIO et al., 2015); and (ii) innovation to create breakthrough products and business model which it is related to the Lean Startup method, and set the value proposition to generate value for target customers (RIES, 2011).

One intended outcome of this study, on a theoretical and practical level, is to identify a preliminary set of activities and tools of NPD and Lean Startup method. As a result, to propose a hybrid development process. Some characteristics are essential such as the "build-measure-learn" loop, faster market tests and early customer feedback (BLANK, 2013; RIES, 2011, 2017).

Despite the Lean Startup method has been used for some established companies, few scientific articles combing these methods are available. Based on the evidence from reading research reports and literature there is an opportunity to create a hybrid model with more activities focus on customer needs.

1.2 RESEARCH QUESTIONS AND OBJECTIVES

Given the theoretical perspectives identified in the literature, the main objective of this research is to develop a hybrid framework for new product development process using Stage-gate process and Lean Startup methodology, which companies should use to improve their product innovation process.

The research question is: how companies can incorporate tools, activities and techniques from Lean Startup at each stage of the traditional new product development process known as Stage-gate process?

According to the general objective, the following specific objectives for the whole understanding of the new product development process are:

1. Identify if a company included digital innovations in its strategy.
2. Identify how a company uses Startup approach.
3. Identify the main methods and tools used in the Stage-gate process.
4. Analyze Lean Startup methods and tools that can be used in the product development process.
5. Define the combination of Lean Startup methods and Stage-gate process to validate the theoretical and hybrid product development process.

6. Identify the key process indicators (KPIs) to measure the new product development process based on Lean Startup methodology.
7. Identify the types of products or services are developed applying the Lean Startup methodology and Stage-gate process.

1.3 RESEARCH STRATEGY

There are some different research approaches, deductive, inductive and combining research approaches (SAUNDERS; LEWIS; THORNHILL, 2009). Likewise, scientists frequently differentiate three specific forms of inference that form the logical basis of a researcher's investigations: deduction, induction, and abduction (WOO; O'BOYLE; SPECTOR, 2017).

Inductive research approach does observations and seek patterns in the data, in other words, relationships among variables that can be generalized from the sample to the population of interest. There are many quantitative data analytic methods that have been devised for doing this sort of study, such as how Big Data methodologies may facilitate inductive research and practices in various organizational contexts; and examples of qualitative inductive research methodology such as ethnography, discourse analysis, rhetorical analysis, and content analysis, as well as ground theory (WOO; O'BOYLE; SPECTOR, 2017).

The deductive approach is based on testing theories through the formulation of hypotheses, and it is a "top-down" approach. In other hands, inductive research assumed as "bottom-up," data-driven and exploratory approach (SAUNDERS; LEWIS; THORNHILL, 2009; WOO; O'BOYLE; SPECTOR, 2017).

Deductive research allows defining the hypotheses which are formulated directly from a theory. If this theory and its hypotheses are the truth, then the results should be as proposed. However, this research approach has the limitation because the researcher does not know whether the premises are correct or not, and the investigation is not a direct test of the premises, only the conclusions that derive from those premises (WOO; O'BOYLE; SPECTOR, 2017).

Research strategy permits the researcher to answer the research questions based on the aims and objectives of the study. The research question is: how companies can incorporate tools and techniques from Lean Startup at each stage of the traditional product development process. It was assumed that is true that the organization is applying/knowing Lean

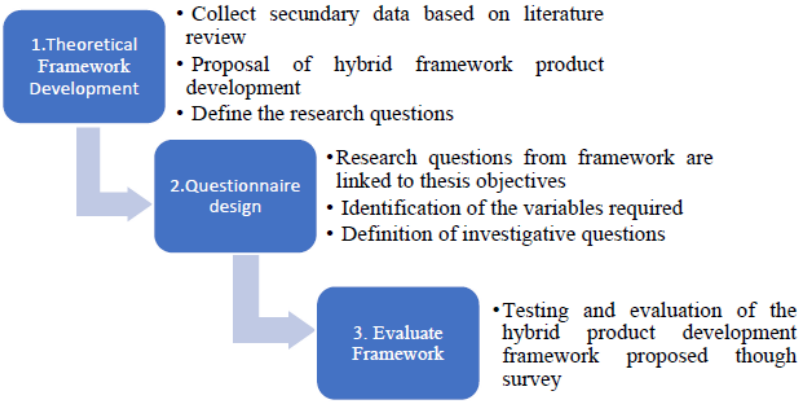
characteristics such as minimum viable product (MVP) and Build-Measure-Learn loops in their product development process. This study is aiming to address how these companies are incorporating these activities and tools in their process. Considering this feature of this study, it will be used the deductive research approach in this dissertation.

1.4 RESEARCH METHOD

The research method will support the observation of how companies use the traditional new product development to perform innovation and how these companies are performing innovation through Lean Startup methodology. To validate this theoretical hybrid product development and business framework, a descriptive and explanatory quantitative research method will be conducted in companies which have a product development process. This research aims to evaluate the phenomenon Lean Startup in established companies and to contribute to the product development field.

Figure 1 shows the research method, and it begins with collecting secondary data written in books, journals and magazine articles – also, primary literature source such as organizations websites and organizations' surveys related to research objectives. These written documents provided qualitative data to create a theoretical framework. Then, the information will be collected to solve the objectives through questionnaire data and analyses. The results of this analysis will validate the hybrid product development framework based on the Stage-gate process and Lean Startup methodology.

Figure 1 – Research method.



Source: Author (2018).

The key practices of Stage-gate process and Lean Startup methodology will be selected according to available literature, documentaries (e.g., organizations' websites, journals, newspapers, interview transcripts) and surveys websites (e.g., Statista and Pew Research Center) published between 2011 and 2018. The information collected and classified will be used to formulate the theoretical hybrid framework and the research questions related to the main activities of the stage-gate process and Lean Startup.

1.5 DISSERTATION STRUCTURE

This master thesis consists of 6 chapters as shown in Figure 2 and and 3. Chapter 1 is the introduction, which describes the problem you are tacking in this study, state clearly how the dissertation aims to deal with this problem, detail the main objective and limit the scope of the study.

In chapter 2 is the Literature Review, it aims to establish a context providing background information for the current study. This chapter includes existing theory and practice for the research topic, preliminary reviews, surveys. Also, it identifies the gaps in the literature and critical review of the strategy, innovation, Stage-gate process and Lean Startup methodology.

Combining these insights, Chapter 2 argues for a need to investigate how companies use Lean Startup method and tools. Based on

that, the most important of both methods are identified in the literature and research questions are posed accordingly in the next chapter.

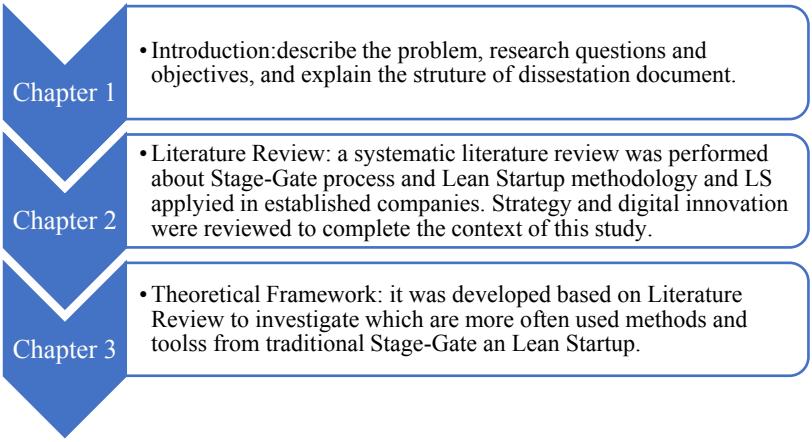
Chapter 3, Theoretical Framework, develops the theoretical framework based on the literature review about digital strategy and innovation, Stage-gate process and Lean Startup method.

Chapter 4, the methodology and research design, provides the foundations, theoretical and procedural description of research method used in this study to collect, present and analyze data. Also, it describes the results based on present facts gained in the survey respondents for each research question showed in the earlier chapters.

Chapter 5 discusses the results and it shows the meaning of the findings for product development.

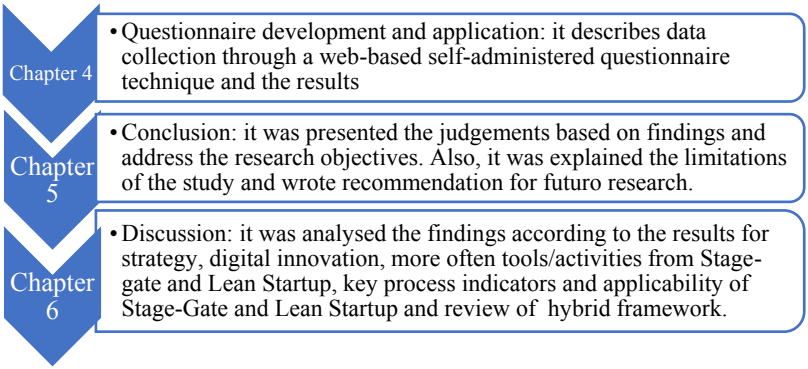
The conclusion chapter shows the judgments based on findings and addresses the research objectives. Also, this dissertation contains three appendixes. Appendix A contains additional literature review, Appendix B describes the introducing of the self-administered questionnaire, and the last appendix contains the questionnaire developed and applied in this study.

Figure 2 – Dissertation Structure.



Source: Author (2018).

Figure 3 – Dissertation Structure (continuation).



Source: Author (2018).

2 LITERATURE REVIEW

The main scope of this literature review is the new product development process known as the traditional Stage-gate process, and more recently the Startup Lean methodology. This chapter begins with a background of the strategy and innovation challenges in the digital era, and both are fundamental to establish new product development process.

Recently, the Lean Startup method has been applied to some established companies. For example, General Electric created an internal startup team to develop fast and test interacting directly with customers one new refrigerator. It is essential to understand what is happing in the world related to the new approach in innovation. The different types of strategy and innovation are briefly discussed. The review mainly focuses on existing theory and practice for Stage-gate process and Lean Startup method. The chapter ends with some examples from established companies using Lean startup tools.

2.1 SYSTEMATIC LITERATURE REVIEW

A systematic literature review (SRL) of new product development process known as Stage-gate and Lean Startup method are performed to aim to cover the relevant literature. Also, the review provides inputs to a theoretical framework of the hybrid development process and answer to the research question:" how large companies can incorporate tools and techniques from Lean Startup at each stage of the traditional product development process?".

The initial step in conducting a robust systematic review is framing a clear and focused research question and objectives (SAUNDERS; LEWIS; THORNHILL, 2009). A well-developed research question not only allows for a more focused and effective literature search, but it also delimits the scope of the systematic literature review (SLR) and defines the population to which the outcomes of the review may apply.

SLR involves defining clear criteria's towards selection and de-selection of research articles consistent with the research objectives, together with evaluating the quality of article (SAUNDERS; LEWIS; THORNHILL, 2009). However, we also defined a secondary criterion, which allows the inclusion of book chapters and conference proceedings. Such inclusions were based on the alignment of these literature with the review objectives.

The Lean Startup method applied in new product development process in established companies is relatively a new area, then it was fixed the year of 2011 as the base year. The details of the review parameters are presented in Table 1.

Table 1 – Review parameters.

Parameter	Description
Review Timeframe	2011 – 2018 (September)
Search Agent	ScienceDirect
Article type	Journals, book chapters, and conference proceedings
Search fields	In title, abstract, and keywords
Language	English
Search terms	new product development, stage-gate process, Lean startup method

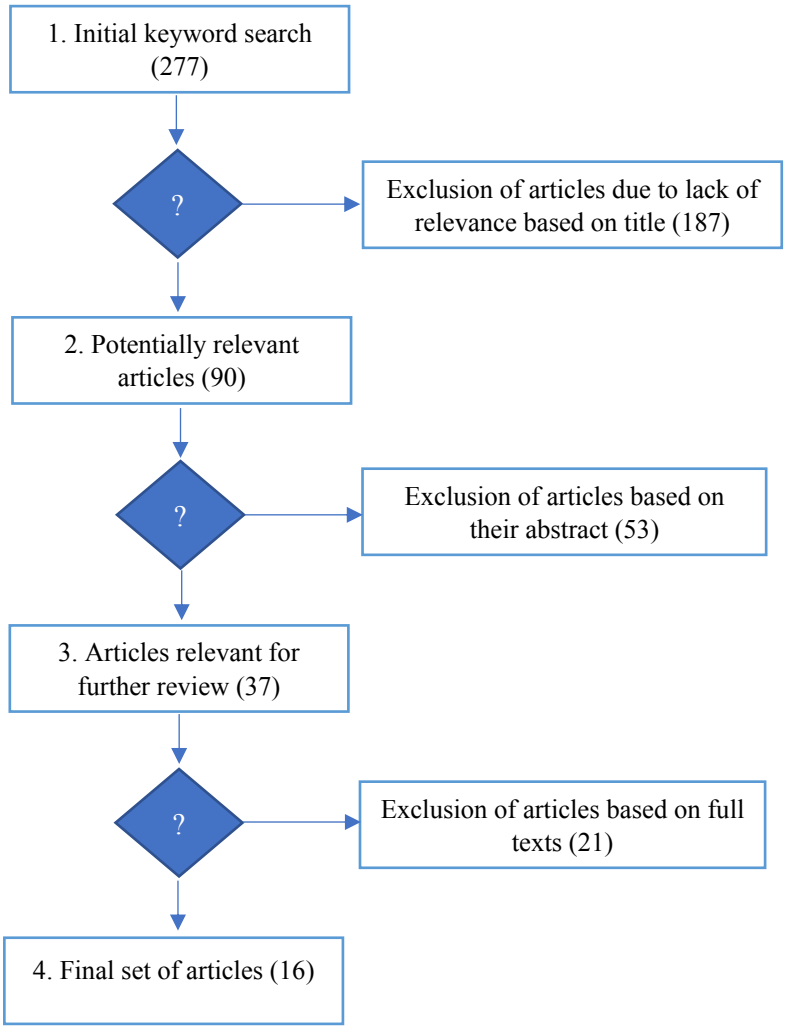
Source: Author (2018).

The article selection process is shown in Figure 4. The criteria are based on the key words combination of strategy, innovation, digital, shifting, challenges, new product development, stage-gate process, Lean startup and large companies. Only those articles are therefore considered, which have an explicit mention of these terms at least in the title or abstract. The initial key words search starting with the following expression: (new product development process OR stage-gate process) AND (Lean startup).

The initial search resulted of 277 potentially relevant articles. All the articles were examined for the title and the abstract to ensure relevance regarding to research questions and objectives. After, it was found 37 relevant articles for the review. These selected articles were read, and their relevance was evaluated. Finally, it was found 16 articles.

After using search terms, we followed the backward snowball method to the references in the identified articles. With a forward snowball method, we followed the digital library lists of articles quoting the identified papers. The most important criteria were relevance to the topic. The articles should emphasis in New Product Development, Stage-Gate process and Lean Startup method.

Figure 4 – Selection process of the articles.



Source: Author (2018).

Also, it was included fundamental articles and books chapters in which they explained the background review of strategy and innovation. It was included not only research from pee – journals in secondary

literature, but also reports, conference proceedings, sites from companies, sites about Lean Startup from grey literature (SAUNDERS; LEWIS; THORNHILL, 2009) which provided an overview of Lean Startup applied in companies. For this primary literature (grey literature) it was used the Google's web search engine.

2.2 STRATEGY

The strategy is one of those fundamental business words, which business managers spend much time thinking about and talking about (MINTZBERG, 1987a). The strategy may be the thing that determines whether companies will fail or succeed. In the study of strategy, there are two central academics contributed with relevant ideas. Michael Porter and Henry Mintzberg have influenced managers around the world how to develop a strategy by a set of rules.

Companies require strategy to concentrate energy and establish the direction of all activities, to define their identity, and to deceive the competition or enable themselves to maneuver through threatening environments. Also, strategy provides a unique understanding of whom they are, creating their fundamental principles and engages their employees to better performance. Furthermore, companies need a strategy to mitigate the risks of the business and implement stability, which permits to managers an understanding of being in control of the organization. As a consequence, the results of the companies arise from the best initiatives and the organizational learning defined by strategy (MINTZBERG, 1987a).

Mintzberg discussed that strategy should not change so much and so fast, even in dynamic markets, because it is ineffective to change the direction constantly, it prejudices to finish the activities and obtain results. A strategy needs stability even that itself is focused on changes; otherwise, it increases the susceptibility of the companies to fail. In this context, strategy protects the companies against distraction. Consequently, it is a force that resists change rather than encourages it. In the final analysis, the author said an obsolete strategy can hide world changes from the companies (MINTZBERG, 1987a).

According to Porter (PORTER; ROACH, 1996), companies should be capable of reacting promptly to dynamic markets and technologies. However, some companies with an emphasis on improving productivity, quality, and speed, managers adopted Total Quality Management, benchmarking, and re-engineering as the unique strategy. They might have misunderstood the meaning of operational effectiveness

and strategy operational. Although operational excellence is important because the companies can reach lower cost and better products quality, it is not enough for suitable business, because other companies too easily copy these management techniques (PORTER; ROACH, 1996).

In contrast, Porter argued that strategy as position is the creation of an exclusive and significant position based on different set of activities combined that will be harder to imitate. Whereas managers frequently attempt to individual components of success such as core competencies, Porter showed that managers must make trade-offs, to choose what not to do, define and align activities of the entire company, creating a clear framework to make daily operational decisions to enhance competitive advantage and sustainability (PORTER; ROACH, 1996).

Porter criticized Japanese companies for essentially focus on operational efficiency, benchmarking and copying each other's ways of operating. Japanese companies have all come to execute business very similarly with lacking strategic vision, which means none of them can have a real sustainable competitive advantage (PORTER; ROACH, 1996).

According to Mintzberg (MINTZBERG, 1987b), there are five meanings to be viewed in term of strategy. This perspective of Mintzberg is known as '5Ps for Strategy'. Strategy can mean a plan, a ploy, a pattern, a position or a perspective. A strategy as a plan is about to intentionally plan the company development, which these previously actions planned conducts the company from the current situation to their future vision.

Mintzberg said that a specific type of strategic planning is a ploy, which is a specific tactic plan to disturb, dissuade, intimidate, or in another way influence the competitors. Also, the author explains a sophisticated strategy focus on persuading people that products are worth, for example, the behavior of the Ford Motor Company when Henry Ford offered his Model T only in black. In this meaning of strategy, the company understanding the past will define a plan to continue the development. This behavior, intentional or not, is a strategy as a pattern (MINTZBERG, 1987b).

Another sense of the word strategy is as position, a strategic and intentional position within a market, among the competitors and customers. Also, this strategy can be a definition of the position in terms of company method of sales, the quality of the product or the price to compete. All activities of the plan are based on market research and projections aim to avoid competition (MINTZBERG, 1987b).

The last definition of 5Ps for strategy refers to organizational culture as a strategy. Companies have different purposes, goals, and

values, which those reflect in their unique mission and vision of the company's business. Some organizations develop new technologies and exploit new markets; others prefer a stable market, and they try to protect themselves from competitors (MINTZBERG, 1987b).

Nowadays, the idea for cooperative behavior has implications in social science, political science, international relations, economics, sociology, and strategy in companies. Axelrod and the biologist William Hamilton studied a scenario in game theory which is called The Prisoners' Dilemma. They explained why cooperation occurs in humans according to behavioral biology and human evolution. One key part of this idea is a variety of strategies were tested in an "Iterated Prisoner's Dilemma" game. Prisoner's Dilemma is a game among the variety of those used in what is called Game Theory (AXELROD, 1984).

The author argued that the approach for strategic situation must consider an iterated non-zero-sum setting, which the effectiveness of any strategy is unlikely to depend on only on the features of that specific strategy, but also on the features of the other strategies against which it competes. In other words, a company influences strategic situations and the results, but it does not have complete influence. What happens to a company also depends on what other companies decide. Also, an effective strategy must consider all the interaction since the begin (AXELROD, 1984).

Robert Axelrod showed through a computer tournament involving professional game theorists from psychology, economics, political science, mathematics, sociology disciplines and users of small computers that one of the simplest strategies called Tit-for-Tat is the best strategy in a repeated game. Tit-for-Tat means a player begins by cooperating, and after it repeats whatever the other player did last time. The effectiveness of the strategy is based on the combination of being nice to prevent undesired conflicts and forgiving to promote cooperation between players (AXELROD, 1984).

The author said the most significant learning of this tournament is the necessity of reducing rebound effects in an environment of mutual power. When a single defection can start long sequences of defections between the players and both sides will suffer. As a result of these computer tournaments, business managers learn, imitate and remove the unsuccessful strategy to avoid to be removed from that role (AXELROD, 1984).

The skill differences among the players can be an important characteristic for achieving success in most real games. Game theory focuses on the choices that are made like Porter's approach to business

strategy. Some sports coaches decide that the skills of the players are more important than the play, others choose a different strategic approach. In the article Skill of Game, the authors said the skills of the players, for example in a basketball team, are specific for that specific game, these skills do not help to play well football. For this reason, the skills might not be too easy to copy (LARKEY; AUSTIN; ZAMIR, 1997). Despite Porter's statements that operational effectiveness is easy to copy, it is not true in most games and might not be true in most businesses.

Another significant development in business planning came from Robert Hayes. He analyzed the traditional strategic planning process called "ends-ways-means" model. The company defines corporate objectives (ends), creates a strategy (ways) to achieve them, and then manages the resources (means) are indispensable to implement this strategy. This approach presumes that the future is predictable once a company defines and executes the objectives and the business growth toward those objectives is measurable and controllable (HAYES, 1985).

Also, this approach applies false stability to the company itself. The managers believe that the company's values and needs will not require modification over the execution of the strategy. Additionally, all these assumptions emphasis on top management responsibility for organizational success and most managers define short-term objectives focusing on rates of growth in profitability, return on investment, and market share. These five-to-ten-year time periods are based on inaccurate forecasts rather than on company visions (HAYES, 1985).

The author noted that it sometimes makes more sense to focus on what the company is good at, and after, what position does company have currently in a market or an industry. He assumed that what the company is good it might not be easy to imitate. Also, the company should invest in the development of additional skills, in the development of additional operational capabilities, consequently, means-ways-ends versus ends-ways-means (HAYES, 1985).

The means-ways-ends is a different vision of strategic planning to the Porter strategic positioning perspective. Porter emphasized choices about the location of a company within its external environment, its position. Hayes said that company internal capabilities are more important for business results than a position in the external environment.

The choices a company makes versus how competently a company makes them, apparently both are important for strategy. However, the difference is in the emphasis that a company put on each other. Whether a company assumes rivals will be able to imitate or

whether it should strategize first then execute, or whether a company can act first and strategize later.

These main definitions of strategy discussed above are still applied in many companies around the world. However, there are new challenges to be considered by companies in their strategy. Instead of companies focus their strategy on long-term competitive advantages, they should search for new advantages such as digital technologies (VIKI, 2017). The next item provides some current strategy examples based on the digital era, which was implemented in some companies.

2.2.1 New strategy for 21th-century companies

The digital innovation is changing the business models and economy. New companies like Uber, which provide a new way to mobility, transformed traditional business, causing many people to stop using taxis. This new business model is an example of how mobile technology changed the traditional business by using applications (HININGS; GEGENHUBER; GREENWOOD, 2018).

Internet connectivity and smartphone applications made it possible for carsharing services to be created as a new business model in last years. Car2go is a German car rental company, which is a subsidiary of Daimler Benz, with 2.4 million members and 14,000 vehicles in over 30 cities in the U.S., Canada, Europe and China (MÄLKKI; STAFFA, 2018).

Digital innovation is changing company strategy as is showed in the survey about the tends of automobile innovation until 2025 (Appendix B). CEO discussed technologies that are going to disrupt their business and they confirmed that connectivity and digitalization are crucial (MÄLKKI; STAFFA, 2018).

A connected car has direct internet access by the factory and it communicates with its environment. This market comprehends the sales of communication hardware and the fees collected for several services. The revenue forecast in the U.S. is US$11bn in 2018 and it will grow by 7% a year and reach US$14.6bn by 2022 (MÄLKKI; STAFFA, 2018).

BMW transformed into a digital platform in 2016 that it calls BMW Connected. The BMW Group through collaborations with tech companies create a strategy to develop connectivity experience in its cars. BMW's Connected Drive have Cortana Microsoft's digital personal assistant, which is available on Windows-powered smartphones, laptops, tablets, and even gaming consoles. This platform enables owners to

access an extensive variety of services of the car (e.g., real-time traffic information or media streaming) (MÄLKKI; STAFFA, 2018).

Moreover, the current data acquisition technologies monitor the manufacturing process through the interaction among machines without people interference. Companies need to understand how this can impact their strategy. Also, they need to reevaluate how their plans, their activities regarding the digital market in a way that develops a better fit strategy to current business or create new business models. If established companies are not careful, they could be surpassed by these startups and other technological disruptions (GIEREJ, 2017).

The Center for Creative Leadership and Corporate Leaders conducted a survey of 100 Europeans VPs and Directors in HR, L&D, Leadership Development, and Talent Management. The objective was figured out from a strategy and leadership perspective how companies are preparing for digital transformation. The survey was conducted from November 2017 to January 2018. The survey shows 69% agree that in their companies have an inspiring vision of how new digital services from automation to the Internet of Things, cloud services to outsourced applications, can create opportunities for efficiency and growth in their company. Likewise, many respondents (79%) believe that their companies know how business is changing due to digitalization and establish a clear digital roadmap to accomplish the company objectives (LEADERS, 2018).

However, some top managers have a superficial understanding of trends and digital technologies, and this lack of knowledge can be high risk for the future of the company. Some managers are investing in digital technologies without knowing if they will generate value for their companies. They need to develop digital plans, which they are responsible for implementing the new strategy (LABERGE; VARNEY, 2018).

2.3 INNOVATION

The innovation has two definitions, the first is the outcome and the second definition is innovation as a process. Innovation as an outcome focus on the introduction of new products and new services, it includes product, process, marketing, business model, supply chain and organizational innovation (KAHN, 2018). The innovation can be incremental or radical, and it is possible to classify six types of product innovations:

- cost reductions;

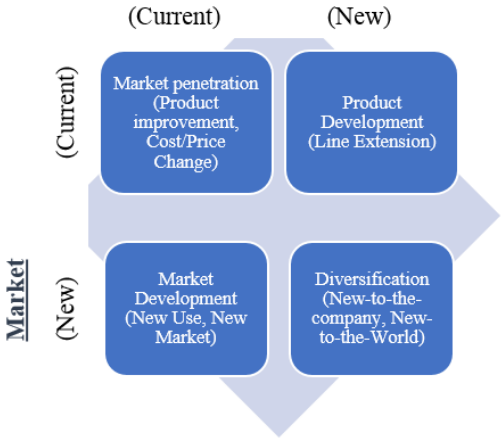
- product improvements;
- new markets (current products taken to new markets);
- new uses (original products positioned in new markets);
- new category entries (new product to the company, but not new to the consumer as a category);
- new-to-the-world products (technological innovations that create an entirely new market). This innovation is defined as radical (KAHN, 2018).

Companies face the challenge of innovation, and the success and continues growth depends on their abilities to create new products and services in the market (COOPER, 2011; HASHMI, 2016). Also, they need to define the innovation strategy in which they create and deliver these new products and services (GRIF *et al*., 2014; KAHN, 2018). Moreover, doubtless, one of the first challenges is to choose between two different approaches: an incremental innovation or a radical approach (GRIF *et al*., 2014; HASHMI, 2016).

Another way to classify the different approaches of innovation considering market (current and new) and the technology (current and new) is the product-market matrix. As shown in Figure 5, there are four strategies: market penetration (current market, current technology), product development (current market, new technology), market development (new market, current technology), and diversification (new market, new technology) (KAHN, 2018).

The potential risk increases when a company changes from a market penetration strategy (incremental innovation projects) to a diversification strategy (radical innovation projects). This product-market matrix is an example of how product innovation can be considered portfolio management (COOPER; EDGETT; KLEINSCHMIDT, 2002b, cited in KAHN, 2018).

Figure 5 – The product-market matrix.



Source: (KAHN, 2018).

A research was conducted in twelve innovation projects in ten large companies concluded that incremental innovation is defined by the development of existing products and processes focus on quality improvements and cost competitiveness, which they emphasize short-term results. This kind of innovation can maintain the companies' competitiveness with the current platform, but only radical innovation can produce a breakthrough innovation in products, processes, and services, and transform existing markets or industries, or creates new ones (LEIFER et al., 2000).

Therefore, companies must manage a radical innovation because it provides a platform for long-term growth. If they fail to develop and introduce disruptive innovation, the companies will take risks of losing customers and markets by the new startups (LEIFER et al., 2000; HASHMI, 2016).

Incremental innovation is not a huge problem for existing companies as a radical innovation, usually their Research & Development department focus on financial results in short-term instead of investing in a high-risk project (LEIFER et al., 2000).

In fact, according to Product Development and Management Association (PDMA) study, New-to-the-world products decreased from 20.4% in the 1990s to 11.5% in 2000s, and improvements and modifications to existing products increased from 20.4% to 36.7% in the

same period. The reason for this change in product development is mainly companies deal with mature markets and focus on short-term results (COOPER, 2011).

Also, companies have difficulty transitioning their radical inventions from the R&D department where new technology is created to new product development processes (GRIF et al., 2014). Radical innovation is a complex process and implies a lot difficult, lengthy and risky process (KAHN, 2018).

A new modern concept of innovation brings back two fundamental elements to create a sustainable business model. The new creations must deliver value to customers and they must be profitable (VIKI, 2017).

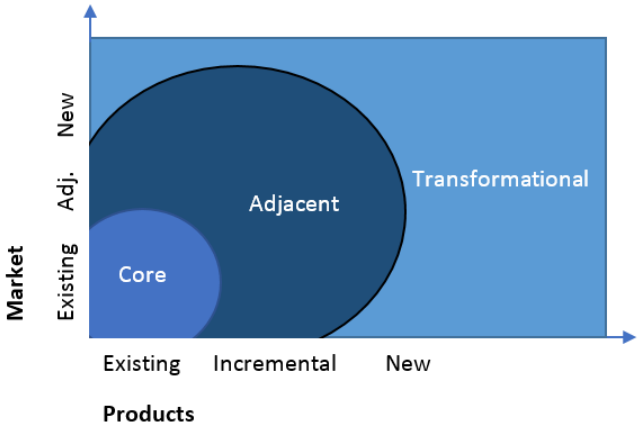
Innovation as a process defines and organizes how the outcomes can be successfully concluded. The new product development (NPD) process is an innovation as a process (KAHN, 2018). The Stage-Gate method is the most common and popular NPD process, which contains stages with several activities and gates as control points between two stages. Standard stages are idea generation, pre-technical evaluation, business case preparation, technical development and testing, and launch (COOPER, 2008; KAHN, 2018; SERGIO et al., 2015).

Additionally, companies should reduce the costs of innovation. The Lean Startup, design thinking, and customer development toolbox provide great methods for lowering the costs of innovation (VIKI, 2017).

Traditional companies normally innovate through business-case, which it has several assumptions about customer needs and expectation to buy new products. Some managers argue that innovation does not need to manage because it is not a linear process. However, a company needs an innovation management process to develop new products (VIKI, 2017).

The strategic goals of the large company must consider having an innovation thesis, in other words, the company must define its vision of the future, sets its boundaries and define which are its goals to reach this vision. As shown in Figure 6, a company should define its products and services portfolios, and classify them by the type of innovation as the core, adjacent and transformational (LABERGE; VARNEY, 2018; POWER, 2014b; VIKI, 2017).

Figure 6 – Innovation portfolio.



Source: (NAGJJ; TUFF, 2012, cited in VIKI, 2017).

2.3.1 Digital Innovation

Digital has profoundly transformed the world in the last decades. There are new ways to communicate, shop and consume media, this trend is persistent across industries, changing the existing companies (GIEREJ, 2017; LABERGE; VARNEY, 2018), driving them to review strategy, operation, and organization (RINGEL et al., 2018). The digital innovation is renovating every single company or industry (BOOTH; MOHR; PETERS, 2016). The Boston Consulting Group investigated the state of digital innovation in the fifty most innovative companies worldwide. Eleven of the fifty companies are digital natives and most companies have defined digital technologies in their strategies (RINGEL et al., 2018).

The most innovative companies focus on big data analytics, the fast adoption of new technologies, mobile products and capabilities, and digital design – all connected to digital innovation. The companies use data analytics for identifying new areas of innovation and business, providing valuable information for idea generation, discovering new markets tendency, and establishing a portfolio (LABERGE; VARNEY, 2018; RINGEL et al., 2018). As a matter of fact, software is changing the world (ANDREESSEN, 2011), company managers are concerned about

automation and information technology (GIEREJ, 2017), the velocity of technological change, customer desire and the significant number of Startups in industry (RIES, 2017).

Companies with robust digital innovation programs using the four types of digital innovation and technology platforms are an advantage in related to others with a weak program. These companies that pursue digital change should review their strategy, how technologies are applied to develop new products, services, and business models. Companies should become digitally capable of developing digital products and services to market (RINGEL et al., 2018).

Most innovative companies use social media or data mining to develop new projects or ideas for growth. Digital transforms innovation strategy, and companies can develop and test new products, services and business model faster and cheaper by applying digitally enabled simulations, 3D printed prototypes, or minimally viable products released to be evaluated by customers in the real market (RINGEL et al., 2018).

Traditional companies are also focused on digital innovation. Citibank developed new products with technologies such as the IoT (Internet of Things), Allianz works with startups in such areas as mobile, data analytics and social media, and Santander Group invests in fintech (Financial technology) products and services. Also, Starbucks and insurance company use mobile data in new product development (RINGEL et al., 2018).

Core players in the European energy industry are changing their conventional models to include digital technologies. The new business models with digital solutions enable better communication between the consumption and production of energy (MIDTTUN; PICCINI, 2017).

The future of the utility will be an entirely digital system, and some companies have already created new products and services based on mobile applications for bill notification, presentment, and payment. Also, these applications will spread into smart homes and connected buildings. The Internet of Things is enabled to create new products for many kinds of companies and different industrial segments. New digital competitors are transforming the traditional industrial, even governments and regulatory bodies pursue to inspire digital measuring (BOOTH; MOHR; PETERS, 2016).

Innovators recognize the importance of data and software to digital innovations. Algorithms execute hundreds of functions, evaluating satisfaction customers, including corresponding products to customers, and determining the quantity and type of inventory the company should purchase. Also, data and software are capable of generating new products

through new insight about customer needs and tendency such as autonomous vehicles (RINGEL et al., 2018).

In this digital era, company strategy must be updated to accelerate innovation and performs faster R&D cycles because software development has faster cycles than traditional physical products. Digital natives such as Apple and Tesla can undoubtedly use their skills to create fast new products and services (RINGEL et al., 2018).

Companies need technical skills such as data scientists, artificial intelligence, mobile devices, and e-commerce experts. Additionally, manufacturing knowledge need people with expertise in Industry 4.0 and the IoT. Large companies figure out that they cannot develop everything themselves; they need partnerships and alliances. BCG survey shows that the number of digital joint ventures has grown by almost 60% in the past four years. Some traditional companies such as auto OEMs are better prepared to fit to this digital era than others because they have been worked closely with suppliers in the last decades (RINGEL et al., 2018).

To establish a relationship with Startups and thereby enhance its innovation culture, WEG selected Startups to develop solutions for industry 4.0, prospecting technology and competitive intelligence, Big Data, Advanced Analytics, monitoring, performance maximization and techniques for products identification (WEG, 2018).

Nowadays, companies can efficiently work with customers and suppliers through different ways to test new products and services, learn what customers' needs and desire, and company can adapt according to the customer feedback loops from the actual market. However, most companies have not embraced this new approach because they cannot trail the customer's digital for experimentation and a test-and-learn approach. Furthermore, all this data often belong to a specific department inside the company, and it is not used in new product development and business decisions (RINGEL et al., 2018).

2.4 TRADITIONAL NEW PRODUCT DEVELOPMENT PROCESS

Many of the companies competing in global markets always recognize new product development (NPD) as a fundamental factor for achieving sustainable competitive results (COOPER, 1994). Researchers and managers are regularly seeking for new methods and practices that will lead them to improve the new product development, resulting in more effectiveness and success for the company (COOPER, 1994).

In the last two decades, the new product development (NPD) has been improved with the objective of creating successful products (GRIF

et al., 2014). NASA built the first Stage-gate process in decade 60, which is named today as Phased Review Process. The initial stage is the idea generation and the last stage is the launch. Several other stages are performed between these stages and there is a decision point or gate at the end of each stage. All these stages are widely an engineering methodology with a set of activities in each stage (COOPER, 1994).

The second generation included Marketing and Manufacturing, as part of the project team. This process requested a significant business and marketing interaction with other areas since the beginning of the project. The stages are the idea, the preliminary investigation, the business case, the development, and the test & the validation (COOPER, 1994).

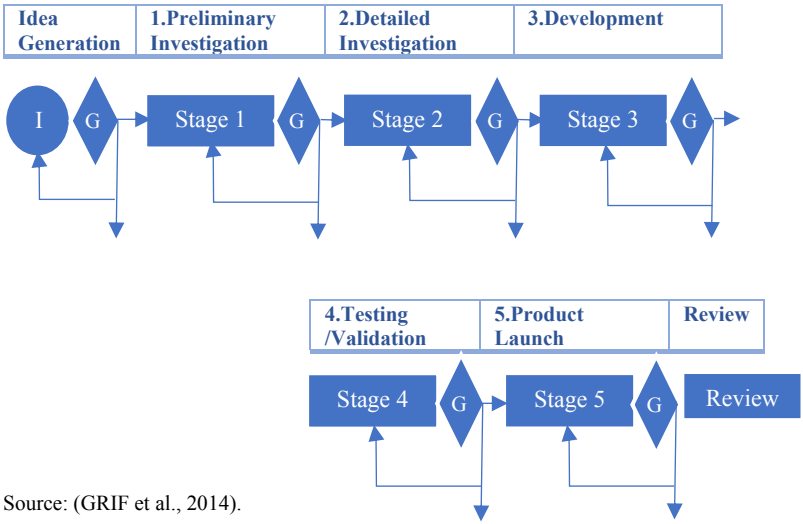
The third generation was attended to reduce lead time of the project, the bureaucracy of the stages and the lack of direction. For example, the project delay occurs because all activities of the stage must be finished before to go to the next stage. While some tasks are critical for the project, some tasks are not vital, and they can be completed in the next stage (COOPER, 1994).

As a result, the third stage-gate process works with a cross-functional (R&D, Sales/Marketing, and Manufacturing) team, it was created the overlapping of the phases, it was defined that shall not all the projects pass through all phases/gates, it will depend on the size and complexity of the project. Also, the inclusion of the fuzzy gate as a conditional decision made by managers based on an analysis of the lead time project and risk management (COOPER, 1994).

Many researchers in the 1980s and 1990s studied NPD processes aim to verify the main aspects of the process associated with the success of the project and establish better new processes. As Stage-Gate™ is a linear model (SERGIO et al., 2015), some researchers aimed to eliminate the re-work between the phases due product concepts that are impossible to be manufactured, when this happens it increases the project lead time (GRIF et al., 2014).

A generic Stage-gate™ process is shown in Figure 7, which describe phases and gates after the idea is selected. There is no early phase describing how this idea was discovered, what are the customers' needs being solved. The literature available focus on stages and gates of the product development process after the idea is selected (GRIF et al., 2014).

Figure 7 – Generic Stage-gate™ method.



Source: (GRIF et al., 2014).

Because this linear process does not contain an idea generation as a phase, it is not adequate for radical innovation (GRIF et al., 2014). The Research studied 132 innovation projects in 72 companies and found that this linear model was used in 53.0% of the cases. Also, this NPD was widely used to obtain incremental improvements by companies with innovation management process. All these phases and gates defined facilitate the NPD use in this type of innovation (SERGIO et al., 2015).

According to Sergio et al. (2015), this traditional NPD manages the uncertainties isolated in each phase. For example, the company starts selecting an idea and defining a plan using tools like market analyses and business plans, and it hopes that the idea will be successful. Also, during the execution of the conversion phase (detailed investigation) this model tries to reduce technological uncertainties with tools like concurrent engineering and project management techniques. In the launch phase, there is not a gate because it was considered that all issues of the product were solved in the early phases (SERGIO et al., 2015).

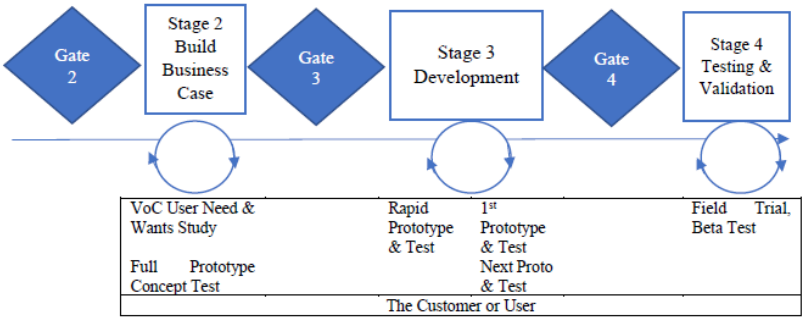
Some literature describes a pre-phase zero stage, which it is developed a preliminary opportunity identification and market and technology analysis (GRIF et al., 2014). The phase zero is also recognized as product concept definition phase and it is directly responsible for incorporating radical innovations in new product development because the customer needs and their respective products requirements will be

discovered. Also, they will be transformed into design parameters, a fundamental task to guarantee the quality of the product in the next phases (LU; LIU, 2016).

In the concept product phase, the team uses brainstorming to generate ideas and to come up with creative solutions to problems. Nonetheless, sometimes it can be a problem to analyze all ideas generated and define the design concepts correctly. Then, the Innovative Design Thinking, a decision method for applying algorithms to optimize the design result, can help the team to improve this concept phase in new product development. For example, the team makes several analytic and synthetic propositions through a closed loop of "specify-ideate-validate" to establish an initial premise (LU; LIU, 2016).

Some companies adapted the idea-to-launch process making improvements through spiral or iterative development. These companies build several versions of the product, test them with the customer, ask for feedback, and revise the value proposition based on customer's needs, as shown in the spiral development in Figure 8 (COOPER, 2011, 2018).

Figure 8 – Spiral development with Build-Test-Feedback-Revise Iterations.

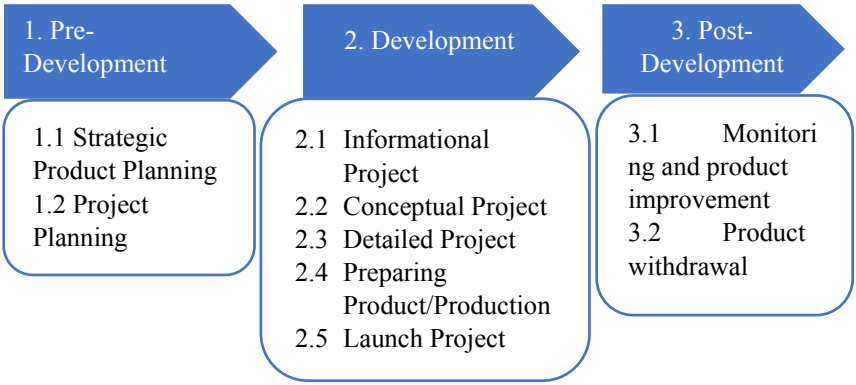


Source: (COOPER, 2011, 2018).

The model proposed by Rozenfeld et al. (2006) aims to integrate marketing and engineering perspectives, as well as to organize best practices developed in academia and business. Figure 9 shows this product development process. In this model, there are three phases. The pre-development stage, there is strategic product planning and project planning. The development phase contains the stages of informational, conceptual, detailed design, preparation of production and launch of the

product in the market are carried out. Also, the post-development stage, comprehends product and process monitoring and product discontinuity occur in the market. The model phases contain decision points (gates) that help the discussion of project deliveries, risk analysis of each phase, financial analysis, per example, allowing the organization to make decisions throughout product development, not only at the end of the project.

Figure 9 – Product development process model.



Source: Adapted (ROZENFELD et al.,2006).

The new product development processes (NPD) have improved products and services by the incremental innovations but this model has not been considered suitable for radical innovations (GRIF et al., 2014). Because, this traditional way to develop product was created to attend to large companies with traditional R&D departments, and this model does not address the level of uncertainty and complexity of the radical innovations projects (SERGIO *et al*., 2015). Also, most of the projects in companies that use this traditional process are less innovative, just some improvements in existing products for existing markets (SERGIO et al., 2015).

Some researchers (Pich et al. (2002) and Rice et al. (2008), cited in Sergio et al., 2015) recognize that new models, tools, and management techniques can be proposed to NPD aim to radical innovation.

Sergio et al. (2015) after to study 132 innovation projects in 72 companies propose a taxonomy of eight different innovation processes understanding the complexity and the kind of innovation, technology, and market. This research considered the traditional model for incremental

improvements in the products. The second and third proposal models considered the initial phase as idea generation, which it is created with the customer; and, some projects the customer can define the product specifications before sale.

However, there are some concerning at this phase. There are unmapped risks about customer needs and a challenge on how to transform the customer requirements (inputs) in the product specification. Considering the complexity of innovation some projects can stop temporary. Then, three of the eight models added a phase to wait for market growth, to wait for technological improvement or both. This stoppage phase in the process aims to solve the uncertainty in the market or technology (SERGIO et al., 2015).

Based on literature researched, all the new product development processes are assumed as linear models with sequential phases and tasks, although reality in companies usually does not to fit in linear models (SERGIO et al., 2015). Companies tend to use non-linear process when they are developing a new product (JIN, 2000, cited in GRIF et al., 2014).

2.5 LEAN STARTUP

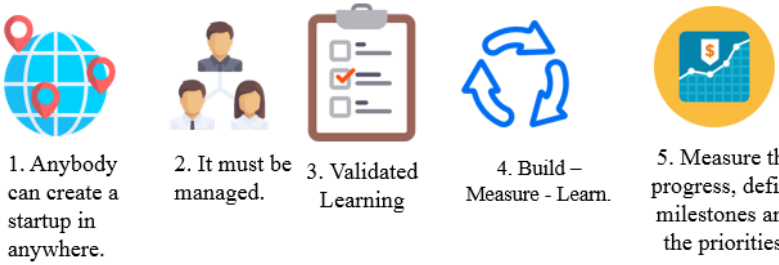
In last years, many products are being made repeatedly. They frequently focus on incremental improvement (HASHMI, 2016). Established companies usually execute their business model, but Startups are creating new models. By definition, Startup is a temporary organization seeking for a suitable and scalable business model (BLANK, 2013; EISENMANN; RIES; DILLARD, 2013). For some companies with the intention to radical innovation, the Lean Methods, such as Lean Startup, Lean Canvas, Lean marketing, Lean customer development, have become the standard in new product development (HASHMI, 2016). Some researchers agree that iterative techniques should replace the traditional NPD model (BLANK, 2013; RIES, 2011).

Radical innovation as a process in new product development is related to accept and manage unknown and high risks. Recent research made by Harvard Business Schikhar Ghosh discovered that almost 8 of 10 Startups failure to reach the success due to these risks (BLANK, 2013). The Lean Startup method can mitigate them because before the new product or service is launched, it is tested and validated with customers (RASMUSSEN, E. S., TANEV, 2016).

The Lean Startup was first created for those companies that develop high technologies innovation, although now this method is widely applied in any company that wants to radical innovation

(RASMUSSEN, E. S., TANEV, 2016). Therefore, any company can apply the five principles as shown in Figure 10 (EISENMANN; RIES; DILLARD, 2013; RIES, 2011, 2017):

Figure 10 – Five Principles of the Lean Startup.



Source: RIES (2011).

1. Anybody can create a Startup in anywhere, but the product, service or market must be entirely new. Hence it has high unknown risks.
2. A startup is not just a product, and it must be managed.
3. It helps to create a successful business. The method consists of continuous learning through tests and validation performed in product and business model for the assumptions formulated.
4. The Build-Measure-Learn activity is essential to transform ideas into products. Through the customer, feedback evaluation is possible to learn when the project must pivot or continue.
5. It is important to measure the progress, define milestones and to know how to define the priorities.

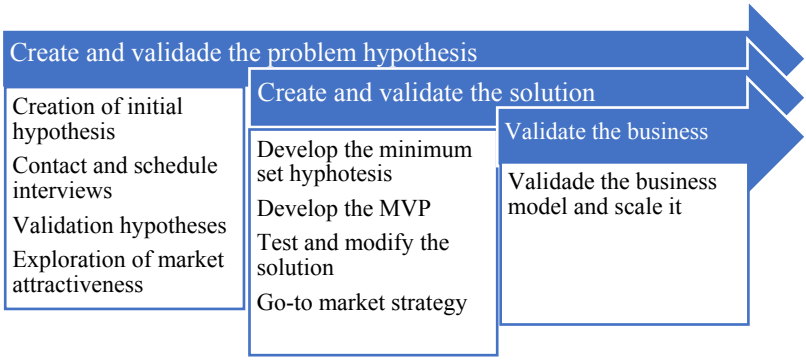
In the Lean Startup method is fundamental to learn about customer needs and desires early in the process (RASMUSSEN, E. S., TANEV, 2016). Also, its fundamental concept is to recognize the importance of business and marketing when starts a new business (RIES, 2011). Then, this method consists of finding a specific customer problem, define the postulates for the new product and new business, test and validate these hypotheses through prototypes with customer evaluation. After some Build-Measure-Learn loops, the unknown facts will be

transformed into product specification and business model features (RASMUSSEN, E. S., TANEV, 2016; RIES, 2011).

As shown in Figure 11, the first phase of this method consists of investigating the needs and the customer's problems and learn about the current solution available. Then, the initial postulates about problem and solution are developed, and these will be evaluated through interviews with the customers. For this initial communication with customers can be used as a virtual prototype or a PowerPoint presentation of the proposed solution. In this phase, it is critical to select the correct customer (RASMUSSEN, E. S., TANEV, 2016).

The purpose of this phase is quick tests the postulates with the customer, measure qualitatively and quantitively the results, and conclude with facts and data if they are correct or not. Also, it defines the market segment and evaluates the size of the market and their competitors. Hence, the main conclusion to be done is the product proposal is good or not good to continue the development (BLANK; DORF, 2012; FURR; AHLSTROMl, 2011 cited in RASMUSSEN, E. S., TANEV, 2016). These product and business hypotheses can be written using the framework Business Model Canvas (BLANK, 2013).

Figure 11 – Overview of the Lean Startup process.



Source: (RASMUSSEN, E. S., TANEV, 2016).

The second phase is to create and validate the proposed solution (the value proposition) aim to understand if the customers will buy it or not. The initial minimum viable product (MVP) is built with characteristics, functionalities, and design basics based on initial

postulates that will solve the customer needs. Also, MVP objective is to accelerate the learning process. The customer's feedbacks help the companies to review the hypotheses and create new ones related to product and business model. Also, a new Build-Measure-Learn loop occurs (RIES, 2011).

This cyclic process is considered very fast when compared with traditional linear NPD (BLANK, 2013; RASMUSSEN, E. S., TANEV, 2016). The output of this phase is: define final solution of the product, estimate cost of the product, set the market segment and estimate its size, discover the potential marketing channel and validate the revenue model (RASMUSSEN, E. S., TANEV, 2016).

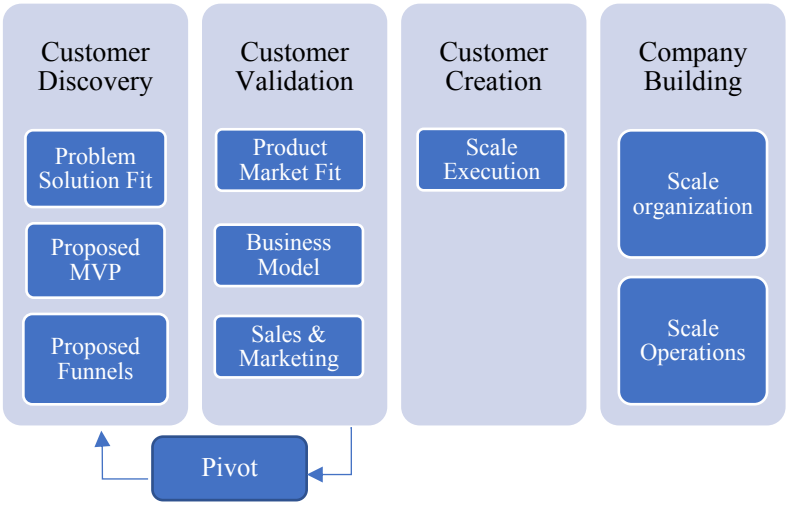
The third phase is focused on validating the business model and scale it. The whole business model is evaluated with remain hypotheses, especially the financial model, which includes fixed and variable costs, margins, customer lifetime and break-even. All these items must be solved before beginning to scale the company. When the company is growing the emphasis changes from Build-Measure-Learn process to traditional measures in business, for example, fulfill the deadlines and the quality standards (RASMUSSEN, E. S., TANEV, 2016).

Steve Blank created another Lean Startup approach known as Customer Development. Figure 12 shows the detailed process for this Lean Startup approach.

The customer discovery phase contains a problem-solution fit, which aims to discover a customer problem and evaluate if it is worth solving the problem. Also, the team defines a set of characteristics for solving the problem using a minimal viable product. In the customer validation phase, which it aims to validate the product-market fit and to answer if the customer wants to buy this solution (COOPER; VLASKOVITS, 2010).

After the customer validation, the company creation phase focus on building a scalable business through a repeatable sales and marketing roadmap (COOPER; VLASKOVITS, 2010). In the company building phase, departments and business processes are defined to support scale (cited BLANK, 2006 in COOPER; VLASKOVITS, 2010).

Figure 12 – Detailed process model for Lean Startup.



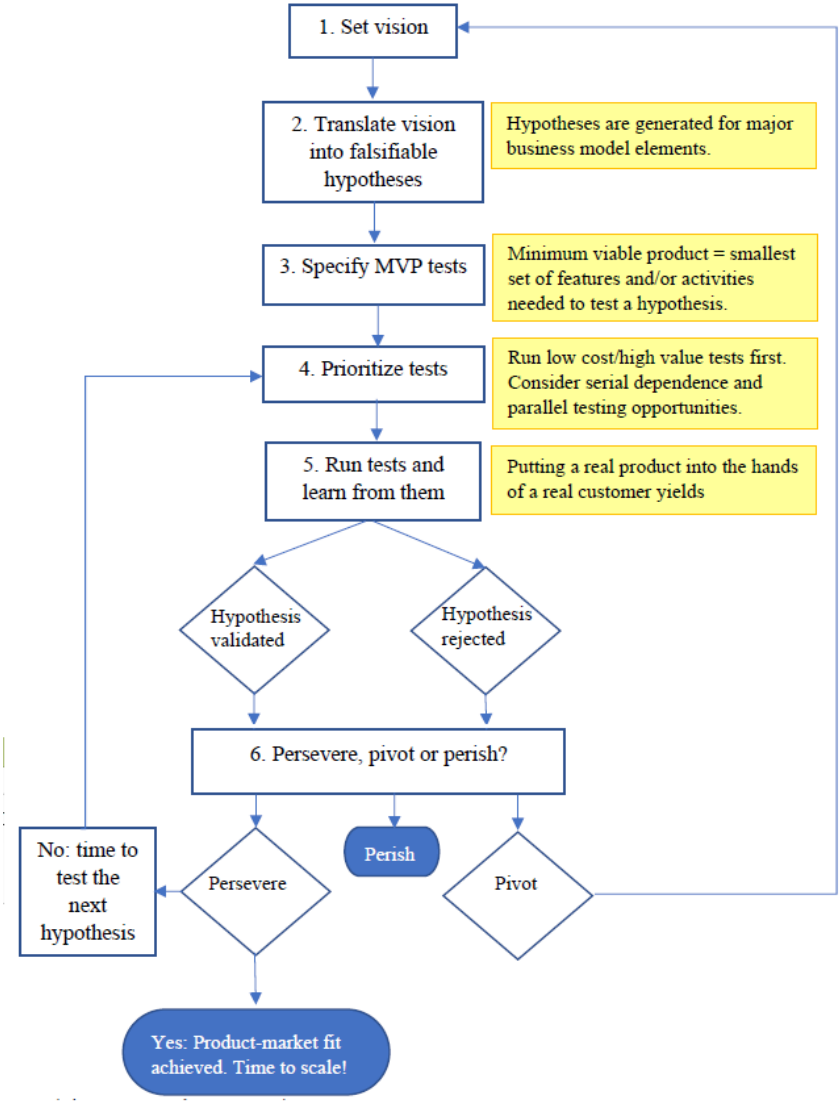
Source: (COOPER; VLASKOVITS, 2010).

A modern company should have not only one traditional system to guarantee the products quality such as Toyota Production System or Six Sigma developed by General Electric but also a system to find new products, services and business model (RIES, 2017). They also need focus on long-term results, cross-functional teams, performs fast tests, define and measure new indicators capable to quantity long-term growth and creates an internal Startup team (RIES, 2017). This internal Startup must combine the know-how of R&D, the knowledge about customers and markets of sales and marketing, and the development discipline of engineering (RIES, 2017).

The author of the book The Startup Way suggests that a company should have an entrepreneurial function to manage new initiatives that will turn into new divisions of the company, and challenge the employees in all departments to find out new ideas and test them with actual customers (RIES, 2017).

A hypothesis-driven approach is shown in Figure 13. It begins with a vision, which is transformed products and business model hypotheses, and then MVP is used to test the main hypotheses.

Figure 13 – Hypothesis-driven process.



Source:(EISENMANN; RIES; DILLARD, 2013).

An entrepreneur takes decisions-based on customer feedback. He needs to persevere, pivot or perish. Pivot means to revise the vision and

perish meant to abandon the idea because it showed not worth. The Startup achieves product-market fit when it has a product that reaches customer's needs, and it is profitable to scale (EISENMANN; RIES; DILLARD, 2013). This process explains in detail the B-M-L loops. However, it does not explain how to scale, which are the steps, methods and tools after achieved product-market fit.

Table 2, 3, 4 and 5 show an overview of the main contribution and type of research method found in the systematic literature review for Lean Startup methodology. There are few scientific articles related to Lean Startup method. These articles used Lean Startup (LS) with other methods such as business model innovation, agile development, and customer development. It was found one article about LS and Stage-Gate process, which it used the Build-Measure-Loops (B-M-L) loops. The research method adopted was almost exclusively qualitative research.

Table 2 – Scientific articles for Lean Startup approach.

Core Theme	Main Contribution	Research Method	Reference
Lean Startup, Business Model Innovation and Agile development	A unified framework to connect Business Model Innovation, Lean Startup Approaches and Agile Development in early stage Digital Startups.	Qualitative research, multi-study case, exploratory study	(GHEZZI; CAVALLO, 2018)
Lean Startup, Experimentation	Proposed model for continuous experimentation based on B-M-L loops for software and services products.	Empirical case study	(FAGERHOLM *et al.*, 2017)
Lean Startup, sustainable business model innovation.	Developed a process for sustainable value proposition design which uses iterative BML of Lean Startup method.	Qualitative research, one case study	(BALDASSARRE *et al*., 2017)

Source: Author (2018).

Table 3 – Scientific articles for Lean Startup approach (continuation).

Core Theme	Main Contribution	Research Method	Reference
Lean Startup and Customer Development	Large-scale research into if and how digital Startups adopt and implement Lean Startups Approaches. Developed practical guidelines for implementing Lean Startup Approaches.	mixed-method combining quantitative (survey with 227 digital Startups) and qualitative (Interviews) analyses	(GHEZZI, 2018)
Lean Startup, Design Thinking	It compares process models for Lean Startup and design thinking and highlights the specific differences and similarities, and it helps to improve either of the two strategies to foster innovative concepts.	Literature review and cases study published	(MUELLER; THORING, 2012)
Lean Global Startup	It offers a critical review of Lean Startup definitions that should be used by younger firms. The second contribution is the summary of the lessons learned from the Lean Startup offer a basis for promoting a similar Lean phase in technology-based global Startup research and practice.	Not described	(TANEV, 2017)
Lean Startup method	It was analyzed the Lean Startup method through a comparison with leading theories and empirical evidence found in the scientific literature.	Not described	(FREDERIKSEN; BREM, 2017)

Source: Author (2018).

Table 4 – Scientific articles for Lean Startup approach (continuation).

Core Theme	Main Contribution	Research Method	Reference
Lean Startup, experiment-driven development	They discovered that companies have an inefficient process to collect customer feedback, perform experiments with customers and learn about customer needs.	Qualitative survey based on semi-structured interviews	(LINDGREN; MÜNCH, 2016)
Build-Test-Learn Stage-Gate	It updated the stage-gate process for Spiral Development—A Series of "Build-Test-Feedback-Revise" Iterations with Customers/Users.	Numerous research studies into NPD	(COOPER, 2018)
Lean Startup, hypothesis-driven approach	It was developed an Hypothesis-Driven Entrepreneurship Process Steps Flowchart based on Lean Startup method.	Not described	(EISENMANN; RIES; DILLARD, 2013)
Lean Startup Agile Dev. Stage-gates Early Phases	The model provides a detailed approach for investigating multiple product ideas in parallel, and it offers operational guidance in terms of stage gates and exit criteria.	Qualitative research, semi-structured interviews with practitioners in nine Startup companies	(BOSCH *et al.*, 2013)
Corporate accelerators, Startups	Developed a framework for design corporate accelerators that add value to the Startups and which generate innovation for the corporation	40 semi-structured interviews with managers of corporate accelerators	(KOHLER, 2016)
Lean Startup, Large companies, internal teams	Investigated how Lean Internal Startup facilitated software product innovation in large companies and identified the enablers and inhibitors for Lean Internal Startups.	multiple case study	(EDISON *et al.*, 2018)

Source: Author (2018).

Table 5 – Scientific articles for Lean Startup approach (continuation).

Core Theme	Main Contribution	Research Method	Reference
Lean Startup, PDCA	PDCA cycle correlation with the Lean Startup methodology for the healthcare segment.	Theoretical	(SILVA *et al*., 2013)
Lean Startup, Axiomatic Design theory, Reduction of risks, inclusion of functional requirements.	It was proposed a novel approach for managing the onset of a new business model or launching a new product/service. for driving managers. It was merged the Lean Start-Up methodology with the Axiomatic Design theory.	Not described	(GIRGENTI *et al*., 2016)
Lean Startup	Explained and explored the Lean Startup methodology and its barriers of implementation in Indonesia.	An explanatory study, case study method	(NIRWAN; DHEWANTO, 2015)

Source: Author (2018).

Even though all positives feature described above can help the business, the Lean methods fall into radical innovation because they put emphases in almost exclusively on customer needs for product development (HASHMI, 2016). Therefore, there is an opportunity to create a hybrid product development by applying the benefits of Lean Startups into the Stage-gate process.

2.6 LARGE COMPANIES USING LEAN STARTUP METHOD

In the last two decades, large companies strategically defined their goals based on cost reduction projects. Some of these companies already agree that they must change the strategy to compete in the market. The new challenge is the creation of new business models. The Lean Startup method is not only for small or new companies but also large companies such as GE and Intuit have started to apply it (BLANK, 2013).

An extensive survey fielded in May 2016 got 170 responses, dozen case studies and interviews about Lean Startup in large organizations. They asked executives about their opinion about benefits applying Lean Startup, who are the partners supporting them and which are the challenges they met (LEADERS, 2018).

Most respondents (82.4%) answered that they already use part of the Lean Startup methodology in their organization, almost 10% answered that they have the intention to use it. The main benefits are: 67% of respondents said that "making decisions based on evidence and data", 61% said "Speed of development", 55.4% Better-quality feedback from customers and stakeholders and 54.2% "Getting out of the building" involve real customers and stakeholders (LEADER, 2016).

In 2012, General Electric (GE) developed a new technique named as FastWorks aim to align new products development directly with customers to avoid build products that they do not want or need. This approach was created with the principles of Lean Startup using the agile development concept trough faster deliverables (sprints) (POWER, 2014a; RINGEL et al., 2018). The GE Appliances used this new approach to build a new refrigerator. The cross-functional team worked in all phases of the project including market research, the engineering team listen to the customers' requirements and learn with them to define the specifications of the product (RINGEL et al., 2018). They made a minimum viable product and performed several times the Build-Measure-Learn loops. Also, this new method included earlier supplier relations, changes in finance, and roles and responsibilities. (POWER, 2014).

In finances, the big challenge was to change the mindset because they usually request until two years of payback. The traditional financial system does not invest in learning something from customers. Traditional financial systems are risk mitigation tool, and these systems don't consider the potential revenue will be lost because the new products are not quickly available to customers, and the potential risk of losing the market. Then, this system was not aligned with the new FastWorks approach and need to be updated to invest money to learn faster and develop new business (POWER, 2014b). As a result, GE developed three key management processes: resource allocation that develops future businesses, faster-cycle product development, and partnering with start-ups (POWER, 2014a).

According to Andreessen (2011), the current technological and economic world is changing to software companies. Also, existing companies are incorporating software and services into their business. They are creating new Startups. The reason for this change is because the

wide accessibility global of the computer and Internet allow revolutionizing industries through software. The current software programming tools and Internet-based services boost new software Startups in several different kinds of companies. The tendency is the digitized world will have more Hi-tech products and services in any company, industry or production and the tendency is to have short product lifecycles and the necessity to make a speedy decision (POWER, 2014b).

Toyota is globally known for its Toyota Production System that outcomes are products with high quality, on time and budget. They recognized that they do not have a system to identify and explore new ideas, find trends such as autonomous vehicle technology and customers preferences (RIES, 2017).

The large companies recognize that is hard to create radical innovation by themselves. Then, they are creating partnerships with start-ups for incubation of breakthrough ideas and equally important, these start-ups can have support from the resources, customer relationships, expertise, and scale of the established companies (POWER, 2014a; RINGEL et al., 2018).

Embraco, a unit from the Whirlpool group, created a Business unit to manage new ideas to develop a new product, new markets, hence new business. In 2016, the company bought a UpPoints Startup, an innovator system to recognize images and to analyze product sales performance in the Market, customers' behaviors, and all information is sent in real-time to industry (EMBRACO, 2016).

Robert Bosch Start-up GmbH, the Bosch Start-up Platform is a Bosch subsidiary, which was launched in 2013. Nowadays, there are seven Startups focus on developing sustainably profitable Bosch business from entirely new business ideas. This platform offers an ideal framework to understand new markets, validate innovative business models, and build a profitable business. The Startup provides methodological support and internal support teams (corporate departments, development departments, mentors or other innovation teams of Bosch) and external network to best attend to the Startups. The infrastructure is used to make faster prototypes and performs tests as well as to do an integrated workshop (ELSÄSSER, 2017).

The concepts of developed by Ries (2011) and Blank (2013) were applied to a corporate environment at Pearson, which creates the Lean Product Lifecycle. This method contains six stages: idea, explore, validate, grow, sustain and retire. The stages idea, explore and validate address exploration for sustainable business models, while the growth, sustain and retire stages aim to validated business models (VIKI, 2017).

The team at Pearson starts expressing their product idea with reasonable assumptions about customer needs and alignment to company strategy. In the next phase, the team directly interact with the customers and confirm their needs, creating the business model, identifying and analyzing the most critical characteristics that the product must have. During the validate stage, the team begins with the minimum viable product to test the solution. They also evaluate other assumptions of the business model such as market demand, revenue models and channels. The product is ready by the end of this stage (VIKI, 2017).

During grow, the team must scale their product by increasing customer numbers, revenues, and market share. In the sustain stage, the product already reaches the maturity level, and the company focuses on to keep the revenues, profitability and customer satisfaction. The last phase, the company decides to remove the obsolete of the portfolio, while confirming that customers are not incommoded (VIKI, 2017)

Some established companies developed partnerships with Startups, this gives opportunities to explore new ideas for their company innovation and creates a platform for long-term growth and innovation (KOHLER, 2016). Establishing corporate accelerators in different industries such as healthcare (Bayer), insurance (Allianz) and entertainment (Disney) aim to innovate their portfolio and increase value through partnership Startup approach (KOHLER, 2016).

Research conducted by StartSe asked established companies their interests of partnership with start-ups in Brazil. The results from around 3,900 respondents were: hire products and services from start-ups (20%), offer products and services to the ecosystem (20%), create own start-up participate (19%), participate in incubation/acceleration process of start-ups (18%), invest in start-ups (12%), acquire and incorporate start-ups (11%) (STATISTA, 2018).

There are some opinions how these Startups units inside large companies should be, such as, they need to be physically separated from the core business unit, and they just need to apply design thinking, customer development, business model canvas, and minimum viable products to reach the success. This success means to deliver value to customers, in other words, the company must create product and services that customers want to buy with profitable financial returns (VIKI, 2017).

Table 6 shows an overview of the main companies that apply part or total Lean Startup method found in the literature review. There are limited scientific articles related to the Lean Startup method and its application in established companies. This information was found in

primary literature such as websites of companies and reports through the google search engine.

Table 6 – Primary literature for Lean Startup applied in established companies.

Company	Lean Startup features/concepts	Result	Reference
GE Appliances	B-M-L loops (faster learning cycles with customers), minimum viable product, get out of the building, use actionable metrics.	New Refrigerator developed with reduction of testing time.	(POWER, 2014b)
Procter & Gamble	B-M-L loops, minimum viable product, Small and dedicated groups	Developed 2 new Products with a reduction of testing time and costs.	(LASHINSKY, 2018)
Toyota	Applied Lean-Startup tactics to discover new approaches to connected-car technology.	Not found	(RIES, 2017)
REGAL BELOIT CORP	Understanding their customers' applications, what they need, and why they need it.	Not found	(LEADER, 2018)
GOODYEAR	Senior leadership team involved as early as possible in the innovation process, small teams.	Not found	(LEADER, 2018)
CORNING	Set hypotheses: "What assumptions are we making?" Get the diversity of thought, and get leadership involved.	Not found	(LEADER, 2018)

Source: Author (2018).

However, large successful companies do not need to give up the traditional business know-how, such as traditional product development. The current products are the current financial source to invest in a new business model. Then, existing companies can radical innovate if they have a portfolio innovation for several products, services and business models (RIES, 2017; VIKI, 2017).

The portfolio describes how the company wants to risk and change. As part of its strategy, the company should include digital capabilities, such as automation, advanced analytics, and big data. It also should invest in new digital businesses (LABERGE; VARNEY, 2018).

2.7 FINAL CONSIDERATIONS

Strategic Planning is essential for companies because it determines whether companies will fail or succeed. It has been discussed in the last decades by some authors and used for many companies around the world. Henry Mintzberg shares how to develop a strategy by a set of rules. He contends that strategy need stability and it will lose its effectiveness if the company continually changes its direction.

Additionally, Hayes developed a traditional strategic planning process called "ends-ways-means" model, which a company created the objectives, define the strategy and then executes the objectives. This model also assumes economic stability throughout many years and might be not suitable for the new economy and its inevitable changes.

Whereas Mintzberg contends a strategy must not always change, Porter argues that companies should be able to react promptly to dynamic markets and technologies and it should create an exclusive position based on its unique set of activities combined that will be harder to imitate.

However, Robert Axelrod developed the concept of cooperation strategy through Tic-for-Tac strategy in computer tournament using Game Theory approach, which a company influences its internal situations, but it does have strong influence outside. What happens to a company also depends on what other companies decide.

The means-ways-ends is a different vision of strategy to the Porter strategic perspective. Porter emphasized choices about the location of a company within its external environment, its position. However, Hayes said that company internal capabilities are more important for business results than the position in the external environment.

Despite different strategy approaches found in the business literature, it seems relevant to a company to adapt, improve or updated its strategy according to new markets and new technologies. Companies around the world are digitally transforming as they are challenged to renew business strategy, develop new capabilities and business models. In this current economic situation, where entire industries are disrupted, traditional companies should be capable of incorporating the digital technologies and fast innovate. Data and information have become core

business assets, sources of new revenue and critical enablers in the digital age.

Companies need to improve their traditional product development process (i.e., Stage-gate.) somehow this process should develop new products and business models according to customers' needs and aligned with digital technologies. Also, a company needs faster develop new products and higher business agility to gain the benefits of new digital technologies.

The traditional new product development known as the Stage-gate process has positive features such as the concept of phases and decision gates. Each phase has defined activities according to the level of product development. The gates have criteria to be approved or reproved, and it helps the manager to make decisions about investments. However, this process has some limitation for radical innovation such as it does not contain an idea generation as a phase and neither focus on customers' needs since the first development phase.

Most companies already agree that they must change their strategy to compete in the market and the benefits for applying Lean Startup approach. They said that the main benefits are making a decision based on evidence and data, increase the speed of development and better-quality feedback from customers and stakeholders. They use one or more these Lean Startup approaches: hire products and services from Startups, create own Startups, participate in incubation or acceleration process of Startups, invest in Startups and incorporate Startups.

GE developed a new process named as FastWorks based on the principles of Lean Startups which aim to develop new product interact directly with customers to avoid build products that they do not want or need. Another example, the Bosch Startup Platform has seven Startups focus on developing a new profitable business.

Give this point, companies should implement the Lean Startup methodology in their current product development process, which Build-Measure-Learn loops enables radical innovate and interacts directly with customer wants throughout the new product and business development. Also, Lean Startup has the advantage of validated learning gates, which occur more often at the end of main activities (i.e., test and validate hypothesis) to be able faster find out whether the new product solves or not the customer's needs.

In general, the company that intends to update traditional product development process using Lean Startup method should understand and analyze what the main change needs to be done related to people, organizational process structure, product development process, and key

process indicators. This dissertation pursued to build a theoretical hybrid framework for product development process adding the most important Lean Startup method and tools/activities.

3 THEORETICAL FRAMEWORK

This chapter covers the theoretical framework that was developed to investigate which are more often used tools and methods from traditional stage-gate and Lean Startup by companies related to the new product development process. First, a hybrid process development framework is developed based on literature review and empirical research. Second, the research questions are developed according to the dissertation objectives and literature review. These questions will be used to develop the questionnaire and to define the variables in the next chapter.

3.1 NEW STRATEGY AND INNOVATION APPROACH

As discussed in the literature review, companies should create a new strategy considering digital innovation. Some companies defined as part their strategy hire products and services from Startups, offer products and services to the ecosystem , create own Startup, participate in incubation/acceleration process of Startups (KOHLER, 2016), invest in start-ups, acquire and incorporate Startups (STATISTA, 2018).

In this theoretical framework, it is aiming to address the strategy based on the creation of internal Startups to build new product development and business model. Also, the literature review supplies the bases to focus on digital innovation. It seems that new products and services developed in established companies are related to digital products such as mobile technologies (ANDREESSEN, 2011; GIEREJ, 2017; RINGEL et al., 2018). Lean Startup method is highly relevant for any strategy or method that aims at creating innovations (RIES, 2011).

The research question aligned with dissertations objectives are:

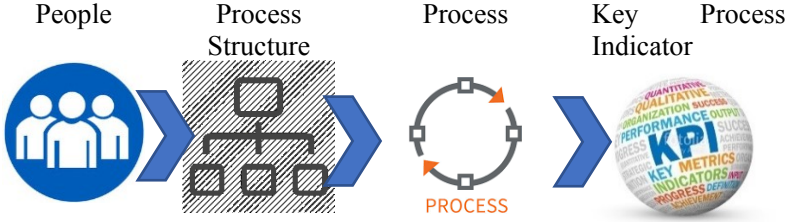
Research Questions 1: Does the company incorporate digital innovations in its strategy?

Research Question 2: How does the company add a startup approach?

3.2 HYBRID PRODUCT DEVELOPMENT PROCESS PROPOSAL

This section explains the four key elements of the management practices in a company as shown in Figure 14. The hybrid framework contains these four elements. The people that work in the company, the structures that are created for them to work within, the processes they use to deliver value and the key process indicators (KPIs) to measure the performance and define goals (EDISON et al., 2018; RIES, 2011; VIKI, 2017).

Figure 14 – Four key elements of the management practices.



Source: adapted (VIKI, 2017).

These four key elements are detailed in the next sections: people, structure, new product development and key process indicator.

3.2.1 People

Lean Startup tools are developed for new product development and business model which are often high-risk projects. Some people naturally like this kind of project. The company should identify those people and provide them a challenging project, an intelligent working structure and the tools (EDISON et al., 2018; RIES, 2017).

The current managers make decisions based on assumptions, and it is difficult for them to evaluate the potential of the new idea. They probably will invest in product ideas close to their current products (VIKI, 2017). Then, an entrepreneurship manager is a missing function in established companies to solve this problem. The manager for the entrepreneurial function has the responsibility to eliminate the barriers and find new ways of growth, transforming insights into new viable products, services and business model (RIES, 2017). An empirical study confirmed which are the reason for the top management to reach the success of the Lean Startup method in companies (EDISON et al., 2018).

3.2.2 Structure

Traditional Stage-Gate process contains a cross-functional view of a product development process, which it involves managers and technical people from marketing, sales, and operations according to the stage of the development (COOPER, 2011). However, established companies turn into bureaucratic organizations with their functional structure such as sales, finance, and marketing. The teams in these departments work via specific processes (VIKI, 2017; RIES, 2011), which each department defines activities such as task allocation in projects.

A modern company must build a cross-functional team that works together focused on customers' needs through the iterative and scientific process. This team has better collaboration, communication, and faster decision-making. (EDISON et al., 2018; RIES, 2017).

In addition, the companies aim to continuous innovation and find new products and business model, they need define an internal Startup team and a distinct organizational structure to support them (RIES, 2017). A research made by O'Reilly and Tushman have evaluated innovations in several companies including IBM, Cisco, Misys, USA Today and Ciba Vision. The conclusion from this research is also companies need to separate their innovation management process from the core business (VIKI, 2017).

3.2.3 New Product Development Process

Most authors argue that the Stage-Gate model does not contain feedback loops, it is essentially a sequential model with limited functional integration. However, according to Cooper (2008, p.1), benchmarking studies reveal that some companies misunderstood the key facets, principles, and methods of the Stage-Gate model. This model is not a linear process, nor a rigid system. In addition, the creator of this model updated the next generation of Stage-gate including spiral development and simultaneous execution (COOPER, 2011, 2018).

The project goes to the next gate, the stage has defined a set of required or recommended best-practice activities, and it gathers information to mitigate uncertainties and risks (COOPER, 2008, 2018).

The main objective of the gate serves as quality control checkpoints, Go/Kill and prioritization decisions points. The structure of each gate consists of deliverables, criteria, and outputs. Each gate set the

deliverables based on standard with clear criteria, such as checklist with must meet and should meet criteria or knock out questions. The outputs for each gate is a decision (Go/Kill/Hold/Recycle), an approved action plan for the next stage, and the definition of deliverables for the next gate (COOPER, 2008, 2011, 2018).

The Stage-gate model has the disadvantage be too rigorous, especially in the early stages of idea and concept generation. Another critique is that it is a linear or sequential process. More iterative loops may be required between idea generation and concept definition, based on validated learning gates obtained through modeling and prototyping (RIES, 2017).

Lean Startup method defines the best way to understand and analyze the market is through experimentation, creating the minimum viable product (MVP), validate or reprove the assumptions, rather than traditional method based on market research (EISENMANN; RIES; DILLARD, 2013; RIES, 2011).

Traditional project management defines as an important objective of the project should stay on budget, finish on time and stay in-scope. In contrast, the goal of the Lean Startup method is to discover the right product or service to develop, what customers want and will pay for it (RIES, 2011).

The traditional project usually creates an elaborate business plan with many assumptions, rather Lean Startup focus on validation of these assumptions through the Build – Measure – Learn feedback loop (RIES, 2011; VIKI, 2017). This loop is at the core of the Lean Startup method (RIES, 2011, 2017).

The Lean Startup experimentation process occurs between the project team and customers. The team creates a new product with more accurate data about customers demand and the team can learn the customers' needs. Market research or a survey could ask what customers thought they wanted or need (RIES, 2011).

Figure 14 shows the hybrid framework developed based on the new product development processes used in most industries, the Stage-gate process follows a sequential set of steps from idea generation to product launch. Companies that cannot use pure Lean Startup methodology can adapt Lean ideas for use in Stage-gate process, creating new hybrid methodology.

The hybrid framework combines different concepts from the Stage-gate process and Lean Startup literature (e.g., COOPER, 1994, 2011, 2018; RIES, 2011, 2017). The framework proposed in this study comprises five elements of the Lean Startup and a five-stage of the Stage-

gate process. The five elements are: (1) set the man hypothesis for product; (2) set the man hypothesis for business model; (3) Validation of learning; (4) Build-Measure-Learn loops; and (5) Build minimum viable product. The five-stage represents an iterative development approach throughout a phase-oriented development process (stage-gate); each product phase can have as many B-M-L loops as necessary in order to satisfy the requirements for each phase-review gate of the product development process.

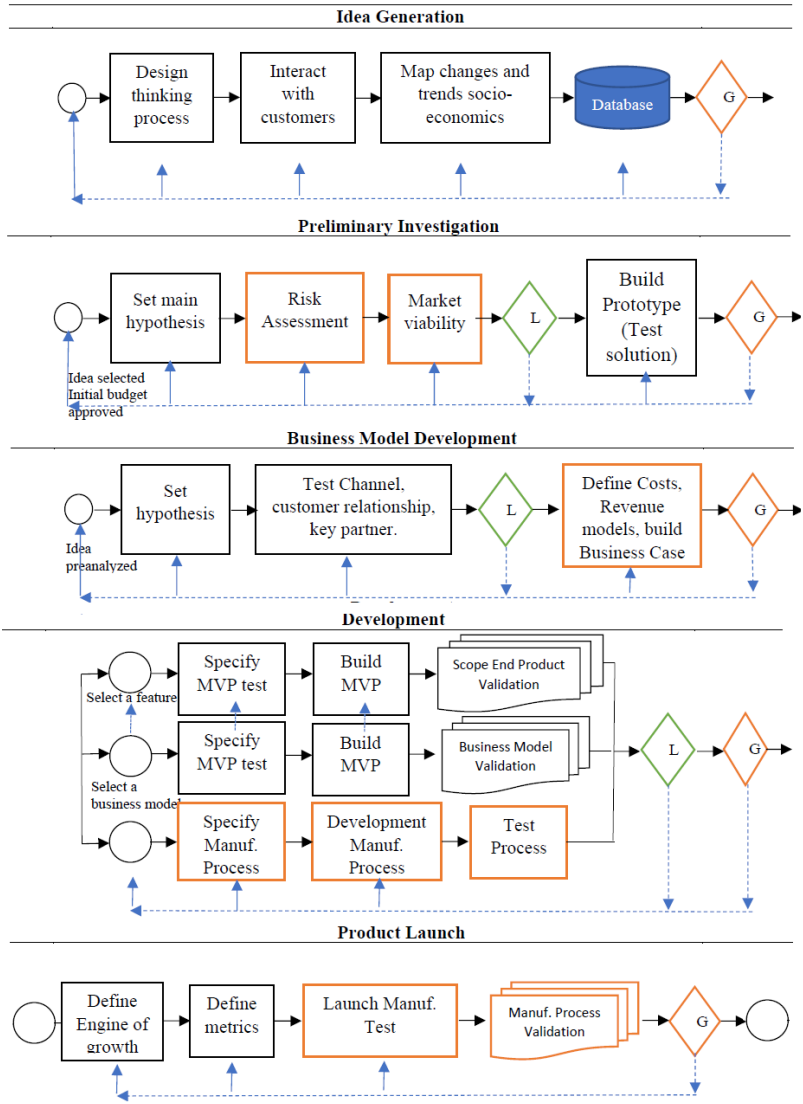
Table 7 describes the legend of the symbols used in the framework.

Table 7 – The legend of the framework.

Symbol	Description
	The beginning of each phase and the termination of the last phase.
	Validation of learning milestone
	Go/Kill decision gate
	Database to store new idea to be developed in the next phases and idea tested and reproved (pivot).
	Activity based on Lean Startup
	Activity based on Stage-gate process
	Indicates the B-M-L loops

Source: Author (2018).

Figure 15 – Theoretical Framework from hybrid product development process.



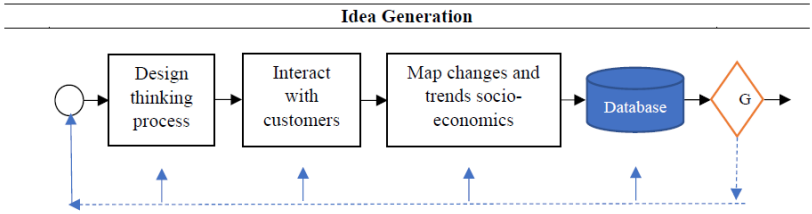
Source: Author (2018).

The next items explain the details of these phases. Each phase proposed is based on the literature review of the Stage-gate process and Lean Startup methodology.

3.2.3.1 Idea Generation

The new product and business development described in this theoretical framework contain three main activities in the stage Idea Generation. Figure 16 shows the activities: design thinking process, interaction with customers as a process and identification of global changes and trends socio-economics. Also, it includes a database to register the insights and the first gate decision at the end of the stage to select the ideas according to company strategy.

Figure 16 – Idea Generation from Theoretical Framework.



Source: Author (2018).

The design thinking process developed by Tim Brown and colleagues at IDEO affords a process and tools for generating ideas. To create ideas, companies need to define cross-functional teams. The different areas working together provide a workplace in which enhances the creativity (VIKI, 2017). Lean Startup methodology does not have an explicit method or technique in the ideation generation phase (MUELLER; THORING, 2012), but it can use ideation techniques to develop new products, services or business model, as they are applied in design thinking, which starts with the “Understand” phase (EDISON et al., 2018; MUELLER; THORING, 2012).

In addition, a company could create others activities to generate ideas such as searching of new available technologies, using the Voice of Customer to discover unspoken needs and customer problems, perform competitive analysis and inverse brainstorming of competitive products, promote an idea-suggestion program to stimulate ideas from the employees, investigate the external innovation ideas and using the

strategic planning to reveal gaps and opportunities in the market (COOPER, 2011). Companies can create internal ideation programs that are focused on undertaking challenges. The winning ideas earn investment for testing, iterating and potentially taking to scale (VIKI, 2017).

A company should interact with customers to understanding their needs (RIES, 2011) and develop a sustainable value proposition talking with customers and important stakeholders (BALDASSARRE et al., 2017).

However, companies must also pay attention to changes and trends in their business environment. This attention allows the company to be aware of the changes and tendencies in socio-economics, technology, Startups, and competitors. Also, it provides insights into new products and business model in future (COOPER, 2011; VIKI, 2017).

For all the ideas created, companies should establish a database on which these ideas can be kept. Also, the ideas that result in failing in the market should be saved on this database (VIKI, 2017).

The decision gate should evaluate the ideas based on criteria and select some ideas to continue the development. A company needs to make decisions based on their strategy and portfolio goals. These selected ideas must be analyzed for their fundamental hypothesis. Reviewing the ideas and identifying risky assumptions helps prepare for testing the ideas in the next stage (VIKI, 2017). This first decision defines resources to the project. If the managers approve the idea, the project goes to the preliminary investigation stage (COOPER, 2011).

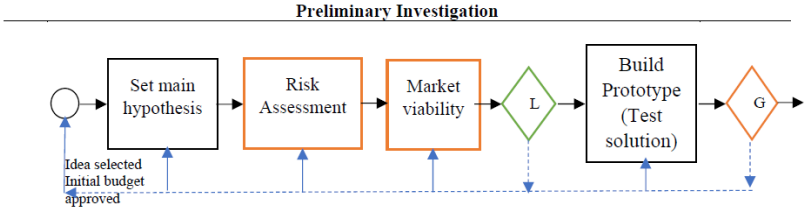
The purpose of this phase is to investigate and validate the problem that customers want to have solved. The criteria for this stage is based on most potential customers said that they (a) need the problem solved, (b) want to pay for a solution, and (c) are willing to participate in solution testing (BOSCH et al., 2013).

3.2.3.2 Preliminary Investigation

After the idea is selected and an initial budget is approved by managers in the previous stage, a preliminary investigation begins with the definition of fundamental hypotheses, identification of risks and preliminary market viability. The outputs from these activities go to Learning Gate or milestones (L) (RIES, 2011), and these steps can be executed as loops. A prototype is built and tested. Managers in the

decision gate evaluate the results. The flow of the preliminary investigation is shown in Figure 17.

Figure 17 – Preliminary Investigation Theoretical Framework.



Source: Author (2018).

Lean Startup method suggests set the main hypothesis explicitly to figure fast out which are true and false (RIES, 2017). The stage-gate process requires the management of risk because risks are inherent to innovation. The uncertainties should reduce as new product development progress and the investment increases as risks go down (COOPER, 2011).

Preliminary market viability defined by Stage-Gate process determines market size, market potential, and probable market acceptance, and define the initial product concept. The main activities should be an Internet search, a meeting with the salesforce, contacts with key users, focus groups, and a fast test of the prototype with potential users. Also, a preliminary technical evaluation is made to evaluate initial times and costs to execute the product and available technical knowledge, legal, and regulatory risks (COOPER, 2011).

The Build-Measure-Learn loops has three main activities. The first activity is to build a minimum viable product based on the main hypothesis. The second activity is measure the results of the tests through the customer feedback. The third activity from B-M-L loops is Learn, then validated learning milestones should be performed several times during the early phase (BOSCH et al., 2013; RIES, 2011).

The preliminary product development begins by testing whether the assumption made about customers' needs are true or not. The team tests the proposal solution whether it solves customer needs and those customers are enthusiastic to pay for it. Whenever possible, these tests should be executed in parallel (FREDERIKSEN; BREM, 2017) not to waste time and reduce costs. The tests results will response the question if customers are willing to buy the product. In this stage, the team uses

prototypes of its product and fast iterate with customers (FREDERIKSEN; BREM, 2017; VIKI, 2017).

The manager makes the decision of approving the budget for innovation based on old tools, such as business plan. At the first stage, the manager needs to change its behavior and approve a little investment to test the assumptions of the ideas. After that, the team will provide information based on the learning process to approve more investment for next phases (VIKI, 2017).

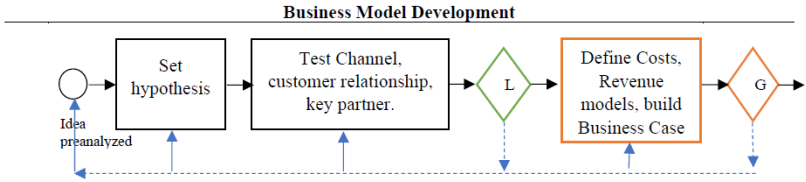
This gate reexamined the project through new information obtained. The managers should evaluate the project using a checklist with must-meet and should meet criteria. The must-meet criteria must be aligned to company strategy and the should meet criteria could be related to product and competitive advantage, market size, technical feasibility, financial reward versus risk (COOPER, 2011).

The purpose of this phase is to define and validate a solution that solves the customer problems. Exit criteria for this stage are when most potential customers said that they (a) accept the solution to solve the problem, (b) want to test the MVP, and (c) express desire to pay for the MVP (BOSCH et al., 2013).

3.2.3.3 Business Model Development

In this stage, the team can focus on validating the remaining parts of our business model as shown in Figure 18. It involves testing the channels, customer relationships, key partners, costs and revenue models. Now, the question is whether a company can produce and deliver the product profitably (VIKI, 2017).

Figure 18 – Business Model Development Framework.



Source: Author (2018).

The Business Case is built at the end of this phase and includes target-market definition, delimitation of the product concept, specification of a product-positioning strategy, and the value proposition,

desired product features, attributes, requirements, and specifications (COOPER, 2011).

At Person company is not required a business plan to move from the idea stage to the exploring stage. The team needs to establish the key assumption that must be tested and estimate the cost of this initial tests. The team needs to validate initial assumption about customer needs and then estimate the cost to build a minimum viable product and test the assumption of its business model. When the team is ready to move from validating grow, a business case is built with the long-term financial projections. In fact, only in this phase, these financial projections succeed because they are built through validated learning (VIKI, 2017).

In previous stage customer needs and desires were translated into a technically and economically feasible conceptual solution. However, during the Business Model development stage, the technical feasibility and risks of the project are completed. Also, information about manufacturability, source-of-supply, costs to manufacture, and investment mandatory are evaluated (COOPER, 2011). These objectives desirability, financially viability and feasibility also were confirmed in a study case in internal Startup teams in large software companies (EDISON et al., 2018).

In addition, a company should evaluate legal, patent, and risks. Finally, a detailed financial analysis should consider a discounted cash flow approach (NPV and IRR), and sensitivity analysis to check the effect of the main hypotheses (COOPER, 2011).

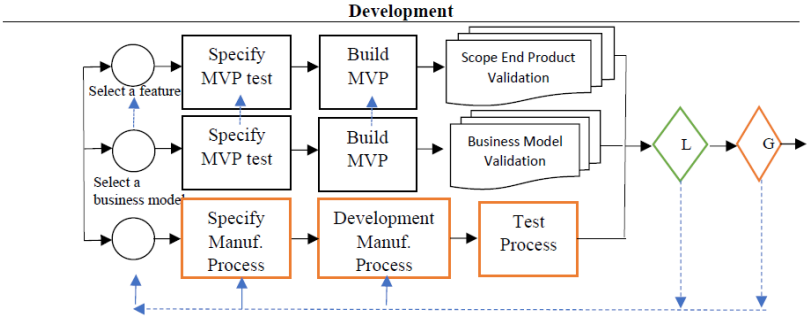
The gate of this stage is critical because the next stage is the Development stage, which has heavy investment. The Business case was built with the advantage of reliable information. Then, if the project is approved in this gate, it has a low probability to fail in the next phase. The project team is now engaged to the development plan and the preliminary operations and marketing plans (COOPER, 2011).

3.2.3.4 Development

Figure 19 shows the development stage. It begins the execution of the development plan and product development. In the previous phase, the prototype was tested, then now the technical team works to build the minimum viable product and certify that the product reaches the customers' requirements and test fundamental business hypotheses (EDISON et al., 2018; RIES, 2011).

For large projects, several milestones and project reviews are established in the development plan. These milestone reviews are not gates to make decisions. In fact, these milestones are validated learning gates (RIES, 2011). The kill-go gate aims to project control and management checkpoints, evaluating if the scope of the project is on time and budget as planned (COOPER, 2011). The interaction and feedback of the customers continue simultaneously with the technical development through B-M-L loops (RIES, 2011).

Figure 19 – Development Theoretical Framework.



Source: Author (2018).

Meanwhile, the project team executes the detailed test plans, market launch plans, and production or operations plans, the financial and business analysis is updated with new information from technical, operations, and customer-feedback development (COOPER, 2011).

A study empirical in large companies confirmed the application of specifying MVP test, build MVP and learning gates in their innovation process (EDISON et al., 2018). The B-M-L loops with customers should support the development of the complete product, in other words, product development and customer development should co-occur (TANEV, 2017).

In addition, the company should develop skills to release quickly minimum viable products with appropriate instrumentation to collect data, design, and know-how to manager experiment plans. As part of this experimentation activity, they should analyze qualitative and quantitative, and store pertinent data, and integrate tests outcomes in the product development process (FAGERHOLM et al., 2017).

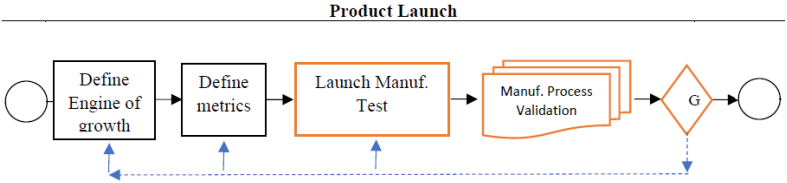
This gate decides to mass produce and sells the product. Also, it is the last gate at which the project can still pivot. The aim is to verify the

quality of the activities and their results. The project results need to meet some defined criteria's such as the projected financial return, the launch, and operations plans continue working as planned, and commercial and market are ready (COOPER, 2011).

3.2.3.5 Product Launch

In the growth phase or product launch, scaling innovative product with new business models can be tough, because the team often works under pressure to grow fast to reach its full potential and incorporate into the core product portfolio. A product launch theoretical framework is proposed as shown in Figure 20.

Figure 20 – Product Launch Theoretical Framework.



Source: Author (2018).

First, the company needs to understand the growth engine that the new product will use to scale. RIES (2011) describes three main growth engines any product can use:

1. The Sticky Engine: This engine address customer retention. The new customers rate buying the product is higher than the quit customers rate.
2. The Viral Engine: This engine based on customers doing the massive amount of marketing through word-of-mouth, network marketing or as a positive reaction of people using the product.
3. The Paid Engine: This engine focuses on paid marketing, advertising or a sales force to promote the growth of the product. The money spent on acquiring new customers must be less than the gains that the customers bring.

When a company decides to test its ideas, the market show to a company which are the right channels and growth engines, a company need to learn how to scale a product and develop the capacity and knowledge to manage this growth engine. After, the company must focus

on continuously improving the engine and confirm if it is appropriately working buy measurement the break-even or profitability (VIKI, 2017).

Companies must create an innovation framework with different products maturity levels to avoid premature scaling. Then, a company can easily identify in which phase is each product or business model (VIKI, 2017).

A company should perform a business model analysis, which teams evaluate the actual business model's viability against the current business environment and emerging trends. Also, new business models can be identified, new channels to reach customers can be created, new customer segments can be targeted and new technologies that reduce the cost of value creation can be acquired. All new assumptions must be tested before scaling it (VIKI, 2017).

The research question for Stage-gate process and Lean Startup method are:

Research question 3: Which are more often tools/activities of the stage-gate used by companies in each development phase?
Research question 4: Which are more important tools/activities of the Lean startup method used by companies in each development phase?

3.2.4 Key Process Indicator

The current system of accountability used by companies to forecast results is based on estimative of selling, internal targets, and external macroeconomic factors. This traditional management tool cannot make accurate forecasts for new product or service because it is unknown, and the market probably is unknown (RIES, 2017).

Companies prioritize their projects based on ROI, traditional accounting, market share (RIES, 2017), NPV and ARR (VIKI, 2017). These are successful methods for developing core products (VIKI, 2017).

In addition, companies have difficult to innovate because the projects based on a company's current assets are often with the highest levels of ROI. In contrast, new products may necessitate the acquisition of new assets. Then, when the company uses criteria to select a project-based on ROI, projects that use current assets will often win (VIKI, 2017).

In contrast, a modern company uses indicators innovation accounting, and it makes incremental investments according to the level of innovation of their products (RIES, 2017; VIKI, 2017). In the idea testing phase, a company makes small investments to permit the teams to

test their assumptions about customer needs and build minimum viable products. As the results are attractive, more substantial investments are made (VIKI, 2017).

Lean Startup method suggests that the reporting KPIs should emphasis in performance teams, the ideas they are developing, the experiments they are performing and the evolution they are making from ideation to scale. For example, measure the quantity of the hypothesis tested and validated (VIKI, 2017; RIES, 2011).

A company should use different KPIs according to type of the activity. In the early phase, the KPIs can measure the number of new products launched, the number of experiments runs, ideas prototyped. In later phases, they can measure tangible results such as Revenue and profits (VIKI, 2017). The difference between activity and KPIs is also suggested by RIES (2011, 2017) by use of vanity metrics and actionable metrics.

A company should invest and define the metrics to follow the project progress based on a product's innovation stage. Whether a project is in the problem investigation or solution validation stages, a company should use revenues or profits as KPIs. In this phase, a company needs to focus on whether the team has collected enough data about customers' needs and they will pay for it (VIKI, 2017).

3.2.4.1 Reporting KPIs

A company must have a process to create, select and review the ideas. An idea has several untested assumptions that need to be converted into knowledge. The project team is aiming to test only the assumptions that are relevant for this specific stage. Then, the team map the risks and begins the tests, reporting KPIs to help the company evaluate the project progress and if the results are reached the goals for this stage (VIKI, 2017; RIES, 2011, 2017).

In this early phase, a company should define metrics for the teams such as the quantity of ideas generated, the quantity of ideas selected, the quantity of ideas reviewed, and the quantity of assumptions identified for testing. After the teams begin the experiments, a company should establish metrics like the number of experiments active, the number of iterations with customers, the number of customer observations and the number of usability tests. As the teams start testing the solution, company should establish as metrics the number of

minimum viable products (MVP) built and the number of customers testing the MVP (VIKI, 2017; RIES, 2011, 2017).

However, these metrics do not show to a company the teams' progress are making. Then, a company needs to define impact metrics such as the number of assumptions validated. For each team, the company should define minimum success or fail criteria before the team starts the tests. As a result of each test, the team should identify the lessons learned, validate or not the assumptions and decide the next steps. Some details need to be mapped regarding customer experience with the product, and if the product meets their needs and customers want to buy the product. Also, some business metrics need to be measured such as the product price is sufficient to cover the costs and make a profit (VIKI, 2017; RIES, 2011, 2017).

In the next phase, a company should measure the revenues, profits, the cost of new customer acquisition. One important metric is the cost-per-learning, which measures the cost of testing the assumptions and transform them into knowledge. This metric also could be time-cost-per-learning. A company can use this metric to reduce the time and costs of the create-test-learn loop. As soon as the team complete problem-solution and product-market, the company can scale the idea (VIKI, 2017; RIES, 2011, 2017).

The research question for key process indicator is:

Research question 5: What kind of KPIs does the company use to measure new product development?

3.2.4.2 Governance KPIs

Some metrics can be the number of products in the pipeline and the number of products at each innovation stage. Also, there are metrics to show the company investment decisions such as the number of ideas submitted for investment decisions, the number of decisions made, the number of products moving between each innovation stage every quarter or year and the average amount of money being invested in products at each stage (VIKI, 2017; RIES, 2011, 2017).

Managers should guarantee that investments are being made in new product development portfolio relate to company strategy. Impact metrics include a measure of the proportion of product ideas that achieve problem-solution fit and product-market fit. Validation velocity is also a

key impact metric for governance KPIs (i.e., how quickly and at what cost teams are moving from one stage to another). Other impact metrics include the number of validated business models at the end of each quarter or year, the returns on product development expense and any process improvements that happened when innovation projects were launched successfully (VIKI, 2017; RIES, 2011, 2017).

3.2.4.3 Global KPIs

A company should measure how well its investments in innovation are contributing to the overall health of the company. The activity metrics for global KPIs mostly focus on the product portfolio and the types of products in it. In this regard, a company can track metrics such as the number of products by type of innovation (i.e., core, adjacent and transformational) and the number of products at each innovation stage. Also, it can measure and track the percentage of products that are aligned with the strategy versus those that are not. Other global innovation activity that can be tracked includes the number of patent filings, Startups partnerships, academic collaborations and the proportion of products built using Lean methods (VIKI, 2017; RIES, 2011, 2017).

The research question for global KPIs is:

Research question 6: Does the company include metrics such as the number of products by type of innovation (i.e., core, adjacent and transformational) and the number of products at each innovation stage?

4 QUESTIONNAIRE DEVELOPMENT AND APPLICATION

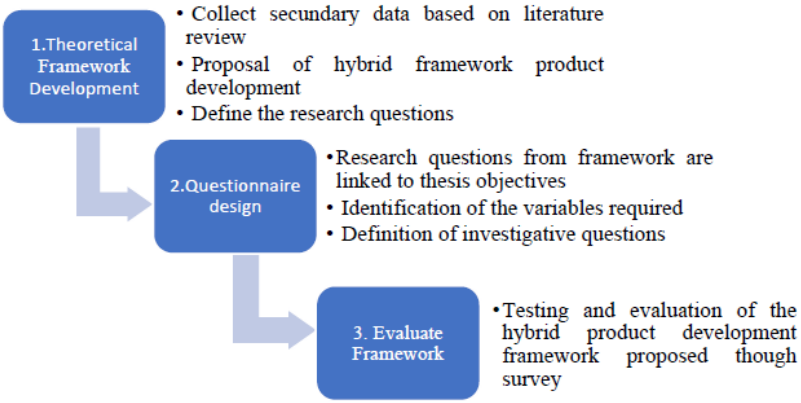
This chapter describes the data collected technique. A self-administered questionnaire is developed based on the previous Framework developed. The results of this evaluation will lead to validate the previous theoretical framework proposed for product development based on the Lean Startup approach. In addition, this study aims to evaluate digital strategy and innovation in companies, the applicability of stage-gate and Lean Startup methodology in different types of innovation (incremental, radical, physical and software products).

4.1 DATA COLLECTION

The Theoretical Framework was developed in the previous chapter as described in Figure 21. This framework will be evaluated through a quantitative method defined as questionnaire technique.

The questionnaire design ensures that essential data are collected and enable to answer the research questions and objectives. This method defines whether the main results are descriptive or explanatory. Also, it identifies the types of variables (opinion, behavior or attribute) necessary to collect data to address each investigative question (SAUNDERS; LEWIS; THORNHILL, 2009).

Figure 21 – Research method.

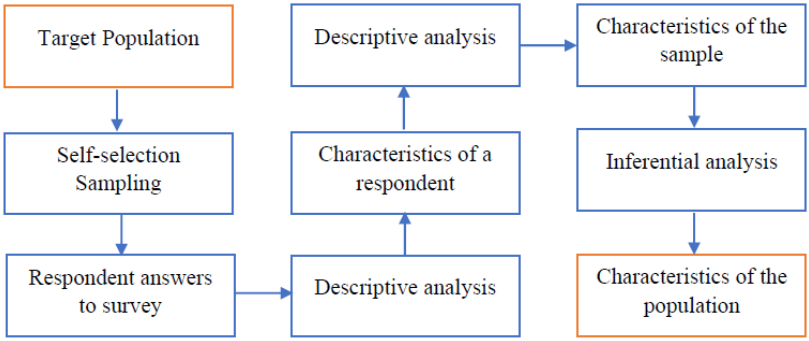


Source: Author (2018).

A survey is associated with the deductive approach. Most of the studies related to business and management adopt this research method. Survey permits the researcher to collect quantitative data from a significant target population. The data can be analyzed using descriptive and inferential analysis tools (SAUNDERS; LEWIS; THORNHILL, 2009).

Surveys are used to study the characteristics of sampling and make inferences to the entire population. Figure 22 shows the main activities used to collect data by defining the target population, choosing the sampling technique and sampling frame. Also, it describes the sequences of activities to make inference relate to the features of the respondents, performs statistical analysis to learn about the features of the samples.

Figure 22 – Survey lifecycle from the target population to inference analysis.



Source: Author (2018).

The population of this study was respondents who work in companies around the world in new product development. The respondents in the sample were product development and design engineers, quality engineers, process development engineers, business managers, project managers, and functional managers. This whole population is enormous and the total amount of companies all over the world is approximately to 200 million. However, it was not found in the literature the number of companies which apply product development processes such as the Stage-gate process or Lean Startup methodology.

The target population is defined as the set of features to be studied. In this study, the description of the target population is specified by:

- Product development: respondents who work in product, service and business development in any department (e.g., operations, engineering, research & development) and with any job role related to product development (e.g., team leader, employee, manager, vice-president).
- Type of industry: no specific industry is a target.
- Geographic boundaries: no specific country is a target.
- Company size: no specific size is a target.

Probability sampling applies statistical theory to select a sample from a more significant population randomly, and then predict the probability the sample will represent the entire population. Probability sampling has some requirements. For example, each element of the population must have a non-zero chance of being selected. Also, the sample must be representative of the target population (SAUNDERS; LEWIS; THORNHILL, 2009).

In this research is not feasible or practical to select a sampling randomly, then it was not possible to assurance those requirements. Self-selection samples are most likely to be committed to take part in the study and have a greater willingness to provide information. Considering these characteristics analyzed, it was selected a non-probability sampling. Self-selection sampling has two steps (SAUNDERS; LEWIS; THORNHILL, 2009):

1. Announce the study needs by sending e-mails with the link of the questionnaire and explain to them what the study involves, as well as the criteria that the respondents must fulfill, their job must be related to the product, service development or business development as defined in the target population.
2. Collect data from the respondents who answer the questionnaire.

In addition, it was looked at Eurostat and DataGov databases to identify comparable data for same variables, and it was not found any data to compare with this study.

4.1.1 Collecting primary data using questionnaire

In this dissertation was structured a self-completed questionnaire, a series of closed-ended questions completed by respondents without

further input from the researcher (SAUNDERS; LEWIS; THORNHILL, 2009). This questionnaire was sent using the web-based questionnaires, and the data collection was from September to October 2018.

Questionnaire collects data request to people answer to the same set of questions in a predetermined order, collecting descriptive and explanatory data about opinions, behavioral, and attributes from people. Opinion variables aim to register how respondents feel about something or what they understand is true or false. Behavioral variables record data about what people or company actions in the past, now or future. Last, attribute variables register respondents features (SAUNDERS; LEWIS; THORNHILL, 2009).

The data requirements in Tables 8, 9, 10, 11 and 12 were defined to ensure that data collected will answer the research questions and accomplish the objectives. Descriptive research defines an opinion, attitude, or behavior considering a sample of people, and it allows that information collected can be statistically inferred on a population.

Table 8 shows the investigative questions and the variable required for the first proposition developed in the Theoretical Framework. The aim is to understand if a company included big data analytics, the speed of adopting new technologies, mobile products, digital design in its strategy. Digital technologies enable idea generation and develop new value propositions, create new products, services, and business models. Then, a company that already has incorporated those digital approached in its strategy, it could recognize the necessity to update the product development process through the Lean Startup method.

Table 8 – Data requirements for the strategy.

Research objective: Identify if a company included digital innovations in its strategy.		
Type of research: Descriptive research, predefined categories a respondent must choose from a list of options.		
Research question	Investigative questions	Variable(s) required
Does the company incorporate digital technologies in its strategy?	What do you feel about your company' vision and tactical strategy to implant digital innovation across the organization?	The opinion of product development engineer or manager about the inclusion of digital innovations in company strategy.

Continuation Table 8 – Data requirements for the strategy.

Does the company use digital technologies to create new products?	What do you feel about how your company uses digital technologies to create products and services?	The opinion of product development engineer or manager about how the company uses digital innovation to create products and services.
	How representative are the answers of respondents? (attribute)	The number of years in product development, description job, age, the gender of respondents.

Source: Author (2018).

Table 9 shows the data requirements for the research question about digital strategy and innovation. The objective is to identify if a company already implemented some Lean Startup approach such as create its own Startup.

Table 9 – Data requirements for the Startup approach.

Research objective: Identify how a company use Startup approach		
Type of research: Descriptive research, predefined categories a respondent must choose from a list of options.		
Research question	Investigative questions	Variable(s) required
Does the company has implemented some Startup approach?	My organization has already implemented several Startup approaches that create or improve its products and services, for example: create own Startup.	The behavior of manager or product/service development engineer about how the company uses Startup approach to create new product development.
	How representative is the company of respondents? (attribute)	Number of employees, type of industry

Source: Author (2018).

Table 10 shows data requirements for research question related to stage-gate process and data requirements for research question associated to Lean Startup method. These questions allow identifying the frequency of use of stage-gate process activities and tools in each phase, for example, gate decision, build a business case and validate product concept. Also, these questions permit to identify the importance of the

Lean Startup method and tools such as Build-Measure-Learn loops and build a minimum viable product in each project phase.

Table 10 – Data requirements for stage-gate process and Lean Startup methodology.

Research objective: Identify the key methods and tools in Lean Startup and stage-gate process. Analyze Lean Startup methods and tools that can be used in the stage-gate process. Define the combination of Lean Startup methods and stage-gate to validate the theoretical hybrid product development.		
Type of research: Descriptive research, predefined categories a respondent must choose from a list of options.		
Research question	Investigative questions	Variable(s) required
Which are more often tools/activities of the stage-gate used by companies in each development phase?	I believe this tool or activity is used in the product development process at…	The opinion of manager or product/service development engineer about activities and elements of the Stage-gate process that they should be included in the product development process.
Which are more important tools/activities of the Lean Startup method used by companies in each development phase?	I believe this tool or activity is important to the product development process at…	The behavior of manager or product/service development engineer about activities and elements of the Lean Startup Approach that they should be included in the product development process.

Source: Author (2018).

Table 11 shows data requirements for research question regarding key process indicators based on Lean Startup approach. The aim is to identify if a company implemented different KPIs to measure the progress of a new idea.

Table 11 – Data requirements for key process indicators.

Research objective: Identify the KPIs to measure new product development based on the Lean Startup Approach.		
Type of research: Descriptive research, predefined categories a respondent must choose from a list of options.		
Proposition	Investigative questions	Variable(s) required
What kind of KPIs does the company use to measure new product development?	What do you feel about how your company defines and measure new products, services, and business development process?	The opinion of product development engineer or manager about key process indicators to measure product development process based on the Lean Startup Approach.

Source: Author (2018).

Table 12 shows data requirements to identify the applicability of Lean Startup method and figure out if these new products are connected to core products or not. The aim is to find if a company is searching for different new businesses.

Table 12 – Data requirements to identify the applicability of Lean Startup method.

Research objective: Identify the types of products or services developed by applying the Lean Startup methodology and Stage-Gate process.		
Type of research: Descriptive research, predefined categories a respondent must choose from a list of options.		
Research question	Investigative questions	Variable(s) required
Does the company apply the Stage-gate process in any size of the project (small, medium and large size)? Is it used in any innovation (incremental and radical)? Can it be only used in physical products development?	How is the applicability (size of the project, the type of innovation and the type of product) of the Stage-gate process?	The opinion of product development engineer or manager about the applicability of stage-gate process.
Does the company apply Lean Startup in any size of project (small, medium and large size)? It is used in any type innovation (incremental and radical)? It can be only used in physical products development?	How is the applicability (size of the project, the type of innovation and the type of product) of the Lean Startup method?	The opinion of product development engineer or manager about the applicability of Lean Startup method.

Source: Author (2018).

4.1.2 Designing the questionnaire

The data requirements detailed in Table 8 to 12 influences the design of each research questions. First, it was tried to adopt questions used in other questionnaires, for example, standardized questionnaires. However, it was not found available those questionnaires. Then, it was adapted a few questions used in other questionnaires, especially the factual questions such as the age and the gender. Most of the research questions were developed in this thesis following the definitions of Saunders et al. (2009). All questions were designed as closed questions, providing some predetermined answers to respondents to choose. This format of questions enables to compute all the answers.

This research used the four types of closed questions to design the questionnaire:

- List of responses: gave a list of option to age, job title, department;
- Category questions: gave a list of categories to collect attribute for the variable amount of year working in product development
- Rating questions: used to collect opinion data and Likert-style rating scale with 5 or 7 chooses. The respondents answered how he or she agree or disagree with the statements.
- Matrix questions: used to collect answers to two or more question.

The self-questionnaire was followed by a covering letter which explained the aims of this survey. The covering letter is on Appendix B – Introducing self-administered research and the questionnaire on Appendix C.

4.1.3 Question coding

The rating and matrix closed questions were pre-coded by using the Likert-style rating in the web questionnaire as showed in Table 13. The questionnaire was built, and all the answer collected in the SurveyMonkey which is an online survey platform.

Table 13 – Use of Likert-style rating.

Type of rating	Five categories (weight)	Seven categories (weight)
Agreement	Strongly agree (5) Agree (4) Neither agree nor disagree (3) Disagree (2) Strongly disagree (1)	Strongly agree (7) Agree (6) Somewhat agree (5) Neither agree nor disagree (4) Somewhat disagree (3) Disagree (2) Strongly disagree (1)
Frequency		All the time (7) Almost all the time (6) Frequently (5) Sometimes (4) Seldom (3) Almost never (2) Never (1)

Source: (SAUNDERS; LEWIS; THORNHILL, 2009).

4.2 RESULTS

This section is an analysis of the data obtained. These results are associated with research questions, and they derived from the results from a web survey conducted in self-selection sampling between September and October 2018. The main purpose of this survey was to perform a quantitative research in companies with the product development process. The questionnaire was sent to respondents which their job is related to product development. In total 127 respondents from Europe, United States and Brazil answered the survey about strategy, digital innovation and Startup approaches in their companies, 83 respondents answer use of activities and tools regarding the Stage-gate process, and 73 respondents completed the survey regarding the importance of Lean Startup methodology in product, service and business development.

4.2.1 Characteristics of respondents

Figure 23 to 24 shows the respondents features, 70% of the total respondents are more than 35 years old and 56% male.

Figure 23 – Age of respondents

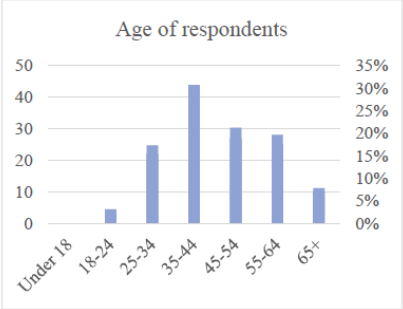
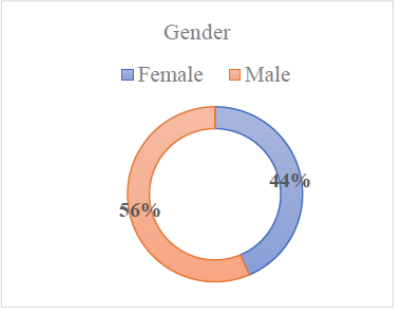


Figure 24 – Gender of the respondents



Source: Author (2018)

In Figure 25 and 26 shows the job role of respondents, 57% of respondents are vice presidents, managers or team leaders and 56% work in product development for at least five years.

Figure 25 – Job role of respondents.

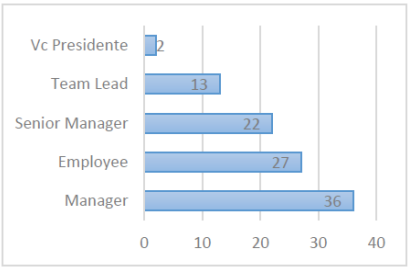
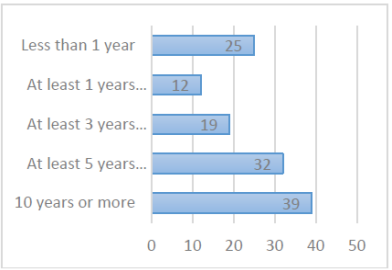


Figure 26 – Respondents years of working in product development.



Source: Author (2018)

The company size is described in Figure 27 which 50% of respondents' companies have more than 1,000 employees. Also, the main segment is stratified in Figure 28, no specified type of industry was the focus. However, 65% of respondents work in manufacturing, Healthcare, Automotive, Logistics, Construction, Food & Beverages, Telecommunications or Airlines & Aerospace.

Figure 27 – Number of employees at companies.

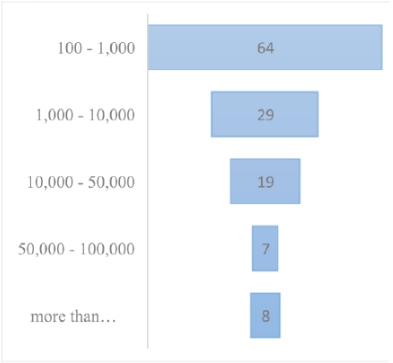
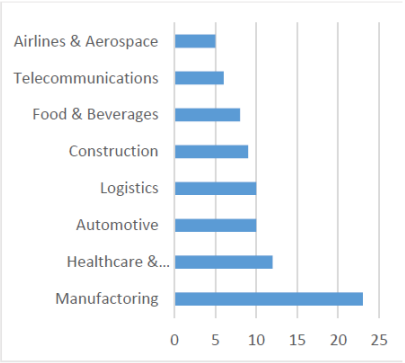


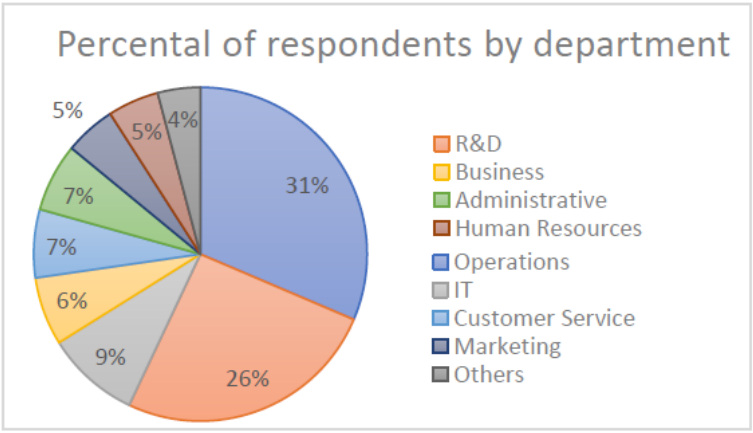
Figure 28 – Principal segment of respondent's company.



Source: Author (2018).

Most respondents work in Operations (31%) or R&D (26%) as stratified in Figure 29.

Figure 29 – Percental of respondents by the department.



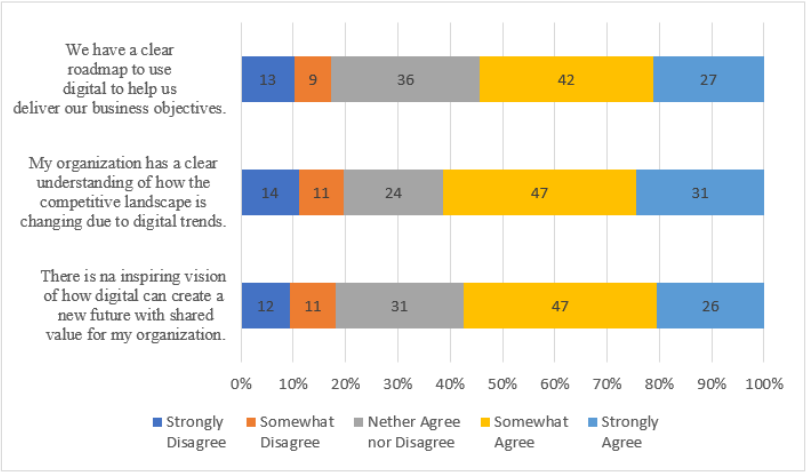
Source: Author (2018).

4.2.2 Strategy and Digital Innovation Results

The top managers should define a vision to address digital strategy. Figure 30 shows the opinion of respondents about what they feel about their company' vision and tactical strategy to implant digital innovation (e.g., big data analytics, the speed of adopting new technologies, mobile products, digital design, Internet of Things) across the company. They answered 69% agree that in their company there is an inspiring vision of how digital can create a new future with shared value for their companies – although there is a significant and concerning 21% who disagree.

Also, while the majority believe that their companies have a clear understanding of how the competitive landscape is changing due to companies and have a clear digital roadmap to achieve business objectives there are significant numbers that do not: 25% and 23% respectively. This result suggests companies need to work on their digital roadmap, through understanding their current situation and the digital transformation innovation objectives.

Figure 30 – Company' vision and tactical strategy to implant digital innovation.

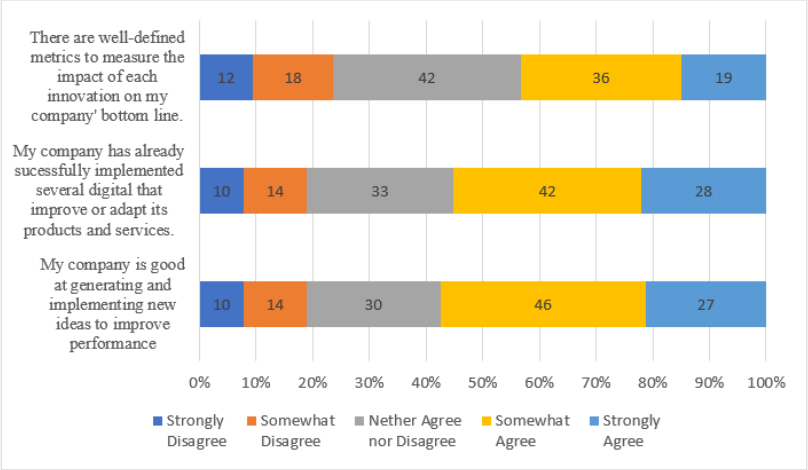


Source: Author (2018).

When asked what they feel about how their companies use digital technologies to create products and services, demonstrate positive results. Figure 31 shows an encouraging 73% of respondents agreed that their companies are good at generating and implementing new ideas to improve performance, which suggests a robust level of digital capability.

Even more positively, 70% of organizations have already successfully implemented several digital initiatives that improve or adapt its products and services, suggesting that the early stages of digital transformation are underway – however, only 55% of companies having clear metrics to measuring their innovation objectives.

Figure 31 – Use of digital technologies to create products and services.



Source: Author (2018).

The respondents said that the company has already implemented some Startup approaches that create or improve its products and services as is shown in Table 14. The 127 respondents selected one or more options related to their company Startup approaches. The result is 32% of the companies hires products or services from Startups to create new ideas of products, 21% create its own Startup, and 19% invest in Startups. Also, there are 19% of companies which did not implement any Startup initiatives, but they will implement in the future. However, there are 25% of companies with no intention to incorporate Startups approaches in their strategy.

Table 14 – Respondents' responses to company implementation Startup approach to create or improve its products and services.

Startup Approach	Responses	Percental
Hires products and services from Startups generating new ideas	41	32%
Create own Startup	27	21%
Invest in Startups	24	19%
Participate in the incubation/acceleration process of Startups	19	15%
Did not implement any Startup approach, but it will implement Startup initiatives in the next years	24	19%
Did not implement any Startup approach, but will not implement Startup initiatives in the next years	31	25%

Source: Author (2018).

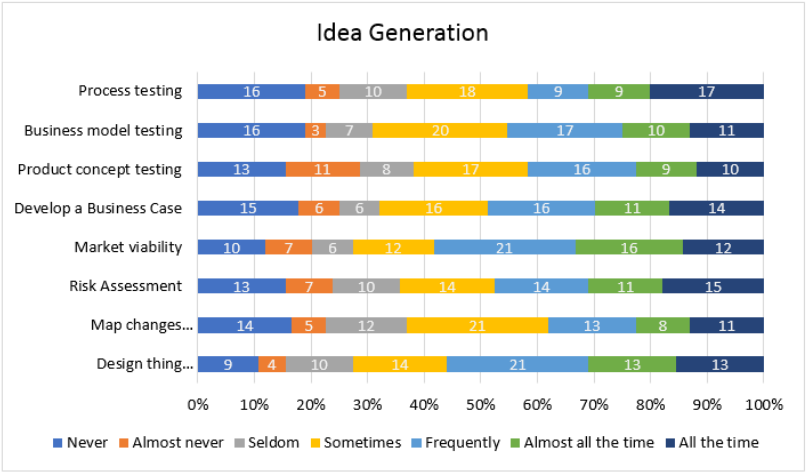
4.2.3 Use of New Product Development Activities Results

This section of the analysis focuses on 83 responses. This smaller number of responses has been filtered for the reason the use stage-gate section of the questionnaire was not completed in full (44 respondents). The use of main activities and tools of the stage-gate process is shown in Figure 31, 32, 33 and 34 indicating a different pattern of response for each phase.

The survey asked participants to select a position between seven sets of frequencies statements for each tool/activity of the stage-gate process enabling respondents to position themselves in the middle between the statements if neither represented their view. On the right side of the questionnaire were demonstrating greater understanding of the frequency of use of these tools in product development in their company.

Figure 32 shows the respondents opinions regarding use tools/activities stage-gate in the idea generation phase. The two main tools were Design Thinking process (at least 57% of the responses were frequently use the tools against to 27% did not use) and market viability (at least 59% frequently use the tools against to 27% did not use).

Figure 32 – Use of the Stage-gate process and tools during the idea generation phase.



Source: Author (2018).

Figure 33 shows the use of these tools during the preliminary investigation phase. The two main activities were Market Viability (60% frequently use) and Risk Assessment (57% frequently use).

Figure 33 – Use of the Stage-gate process and tools during the preliminary investigation phase.

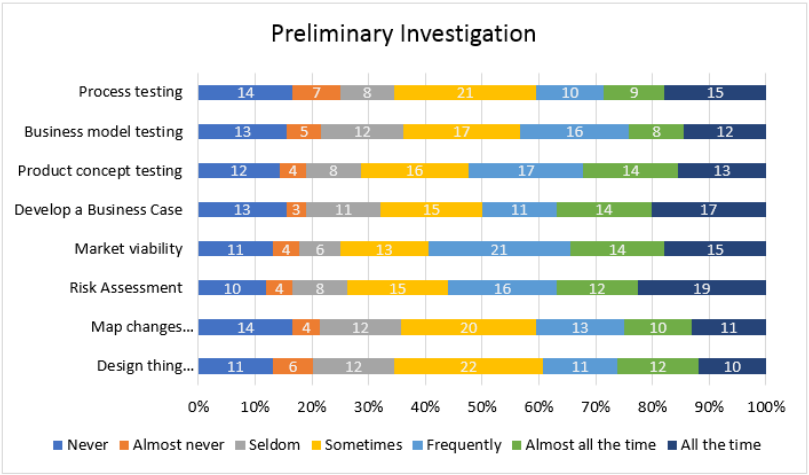
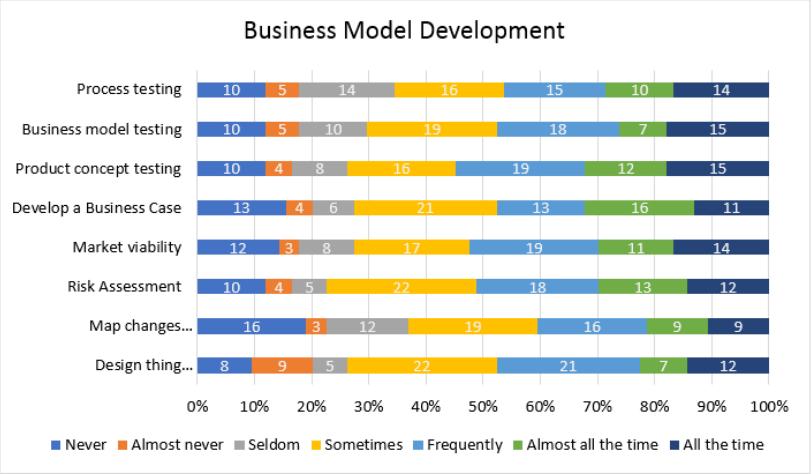


Figure 34 shows the use of these activities and tools during the business development phase. The two main activities were Product Concept Testing (55% frequently use) and Market viability (53% frequently use, 28% seldom or almost never use).

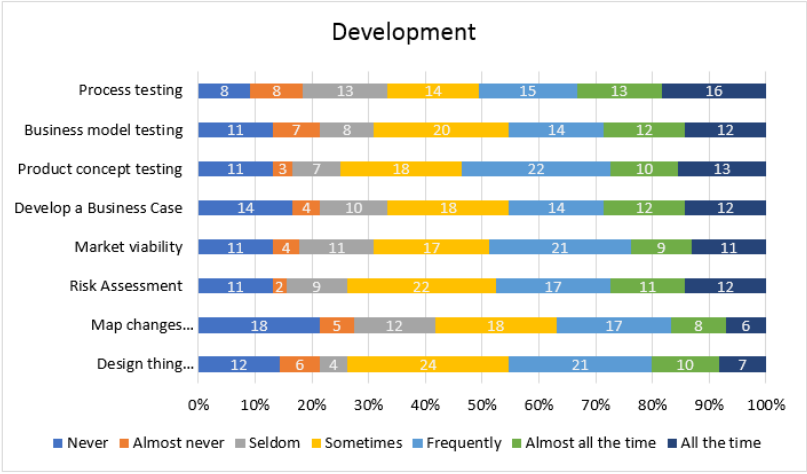
Figure 34 – Use of the Stage-gate process and tools during the business model development phase.



Source: Author (2018).

Figure 35 shows the use of these activities and tools during the development phase. The two main activities were Product Concept development (55% frequently use) and Process Testing (53% frequently use, 35% seldom or almost never use).

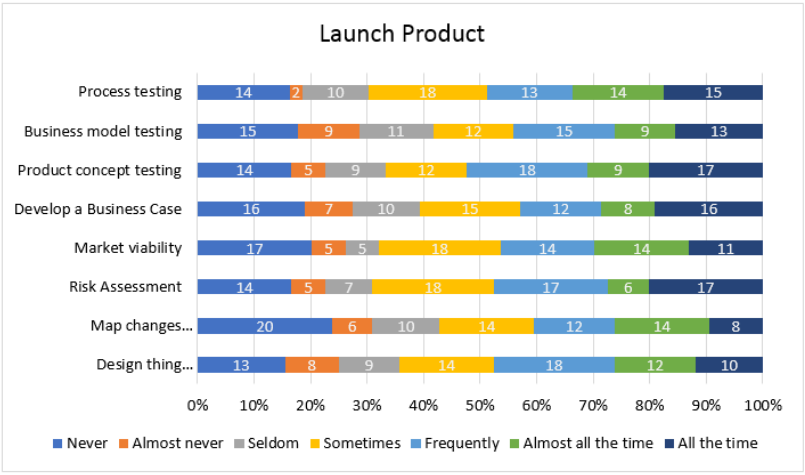
Figure 35 – Use of the Stage-gate process and tools during the development phase.



Source: Author (2018).

Figure 36 shows the use of these activities and tools during the launch product phase. The two main activities were Product concept testing (53% frequently use) and Process testing (51% frequently use, 31% seldom or almost never use).

Figure 36 – Use of the Stage-gate process and tools during the launch product phase.



4.2.3.1 Testing for significant relationships and differences

In Tables 15, 16, 18, 19, 21, 22, 24, 25, 27, 28, 30, 31, 33, 34, 36 and 37 show the evaluation result of the relationship between the variables:

- size of the company: two level (small: less than 1,000; large: more than 1,000)
- activity/tool: one level (design thinking, map changes, market viability, develop a business case, product concept testing, business model testing, and process testing).

All results show p-value higher than 0.05, therefore the relationship is not statistically significant. However, Business Model testing in Table 23 had p-value lower than 0.05, so there is statistical significance between this variable and the size of the company. Large companies have a higher average than small companies, so large companies more often use this tool during the business development phase.

Tables 17, 20, 23, 26, 29, 32, 35 and 38 show the evaluation result of the relationship between the variables:

- activity/tool: design thinking, map changes, risk assessment, develop a business case, product concept testing, business model testing and process testing.
- the phase of the product development: idea generation, preliminary investigation, business development, development and launch product.

All results show F lower than F critical and p-value higher than 0.05, so the relationship between tool/activity variable and the phase of the product development is not statistical significance.

It is fundamental to evaluate if the sample size collected is enough for the analysis to understand how the results are statistical significance. The ideal sample size is 384 answers for size of population 1 000 000 at a 95-confidence level and 5% margin of error. However, it is recommended the minimum number of 30 samples for each category within the total sample for statistical analyses provides a useful rule (SAUNDERS; LEWIS; THORNHILL, 2009).

Table 15 – Results test-t from design thinking for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.558	4.415	4.116	4.073	4.258	4.317
Variance	3.300	3.449	3.439	3.469	3.671	2.722
Observations	43	41	43	41	43	41
p-value	0,721		0,915		0,876	

Source: Author (2018).

Table 16 – Results test-t from design thinking for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	4.186	4.049	4.256	3.927
Variance	3.440	2.847	3.433	4.169
Observations	43	41	43	41
p-value	0,724		0,441	

Source: Author (2018).

Table 17 – ANOVA: Single factor for Design thinking in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	9.867	4	2.467	0.733	0.569	2.393
Within groups	1395.417	415	3.362			
Total	1405.283	419				

Source: Author (2018).

Table 18 – Results test-t from map changes for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	3.698	4.268	3.767	4.341	3.767	4.121
Variance	3.359	3.851	3.611	3.680	3.611	3.659
Observations	43	41	43	41	43	41
p-value	0.172		0.172		0.397	

Source: Author (2018).

Table 19 – Results test-t from map changes for idea generation, preliminary investigation and business development phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	3.558	3.853	3.720	3.853
Variance	2.967	4.078	3.587	4.978
Observations	43	41	43	41
p-value	0.472		0.769	

Source: Author (2018).

Table 20 – ANOVA: Single factor for map changes in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	6.79523	4	1.69881	0.455381	0.76847	2.39343
Within groups	1548.16	415	3.730522			
Total	1554.96	419				

Source: Author (2018).

Table 21 – Results test-t from risk assessment for the idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.279	4.146	4.628	4.585	4.372	4.512
Variance	4.254	4.128	4.001	3.749	3.668	2.956
Observations	43	41	43	41	43	41
p-value	0.767		0.921		0.725	

Source: Author (2018).

Table 22 – Results test-t from risk assessment for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	4.070	4.634	4.186	4.317
Variance	3.685	2.838	4.536	3.772
Observations	43	41	43	41
p-value	0.157		0.769	

Source: Author (2018).

Table 23 – ANOVA: Single factor for risk assessment in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	8.43809	4	2.10952	0.564219	0.688759	2.39343
Within groups	1551.61	415	3.73884			
Total	1560.05	419				

Source: Author (2018).

Table 24 – Results test-t from market viability for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.512	4.415	4.279	4.854	4.186	4.610
Variance	3.256	4.049	4.254	3.028	3.536	3.794
Observations	43	41	43	41	43	41
p-value	0.816		0.172		0.313	

Source: Author (2018).

Table 25 – Results test-t from market viability for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	4.046	4.439	4.093	4.121
Variance	3.426	3.252	3.896	4.560
Observations	43	41	43	41
p-value	0.328		0.949	

Source: Author (2018).

Table 26 – ANOVA: Single factor for risk assessment in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	10.94286	4	2.735714	0.74063	0.56469	2.39343
Within groups	1532.905	415	3.693746			
Total	1543.848	419				

Source: Author (2018).

Table 27 – Results test-t from Develop a Business Case for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.070	4.341	4.116	4.707	3.907	4.707
Variance	4.114	4.330	4.343	3.912	3.943	3.212
Observations	43	41	43	41	43	41
p-value	0.546		0.187		0.056	

Source: Author (2018).

Table 28 – Results test-t from Develop a Business Case for development and launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	3.977	4.366	3.883	4.220
Variance	3.595	4.138	4.153	4.826
Observations	43	41	43	41
p-value	0.367		0.469	

Table 29 – ANOVA: Single factor for Develop a Business Case in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	6.1285	4	1.532	0.3760	0.8257	2.3934
Within groups	1690.8	415	4.074			
Total	1696.9	419				

Source: Author (2018).

Table 30 – Results test-t from Product concept testing for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.023	3.854	4.395	4.366	4.674	4.317
Variance	3.642	3.928	3.863	3.688	3.653	3.471
Observations	43	41	43	41	43	41
p-value	0.690		0.944		0.388	

Source: Author (2018).

Table 31 – Results test-t from Product concept testing for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	4.395	4.439	4.372	4.243
Variance	3.864	3.002	4.096	4.539
Observations	43	41	43	41
p-value	0.914		0.778	

Source: Author (2018).

Table 32 – ANOVA: Single factor for Product concept testing in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	15.880	4	3.9702	1.06171	0.37508	2.39343
Within groups	1551.8	415	3.7394			
Total	1567.7	419				

Source: Author (2018).

Table 33 – Results test-t from Business Model testing for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	3.977	4.244	3.884	4.341	3.860	4.805
Variance	3.690	4.039	3.915	3.480	3.456	3.211
Observations	43	41	43	41	43	41
p-value	0,535		0,279		0,020	

Source: Author (2018).

Table 34 - Results test-t from Business Model testing for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	3.884	4.585	3.791	4.171
Variance	3.724	3.345	3.931	4.545
Observations	43	41	43	41
p-value	0,0913		0,399	

Source: Author (2018).

Table 35 – ANOVA: Single factor for Business Model testing in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	5.8	4	1.45	0.3835	0.8204	2.3934
Within groups	1569.1	415	3.7808			
Total	1574.8	419				

Source: Author (2018).

Table 36 – Results test-t from Process testing for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.163	4.073	3.977	4.244	4.093	4.463
Variance	3.949	5.120	3.785	4.539	3.515	3.705
Observations	43	41	43	41	43	41
p-value	0.847		0.550		0.374	

Source: Author (2018).

Table 37 – Results test-t from Process testing for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.163	4.073	3.977	4.244	4.093	4.463
Variance	3.949	5.120	3.785	4.539	3.515	3.705
Observations	43	41	43	41	43	41
p-value	0.847		0.550		0.374	

Source: Author (2018).

Table 38 – Results test-t from Process testing for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.163	4.073	3.977	4.244	4.093	4.463
Variance	3.949	5.120	3.785	4.539	3.515	3.705
Observations	43	41	43	41	43	41
p-value	0.847		0.550		0.374	

Source: Author (2018).

Table 39 – Results test-t from Process testing for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	4.279	4.732	4.302	4.415
Variance	3.825	3.251	4.216	3.999
Observations	43	41	43	41
p-value	0.274		0.800	

Source: Author (2018).

Table 40 – ANOVA: Single factor for Process testing in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	9.22381	4	2.305952	0.5821	0.675729	2.3934
Within groups	1643.83	415	3.961044			
Total	1653.05	419				

Source: Author (2018).

4.2.4 Importance of Lean Startup Method and Tools Results

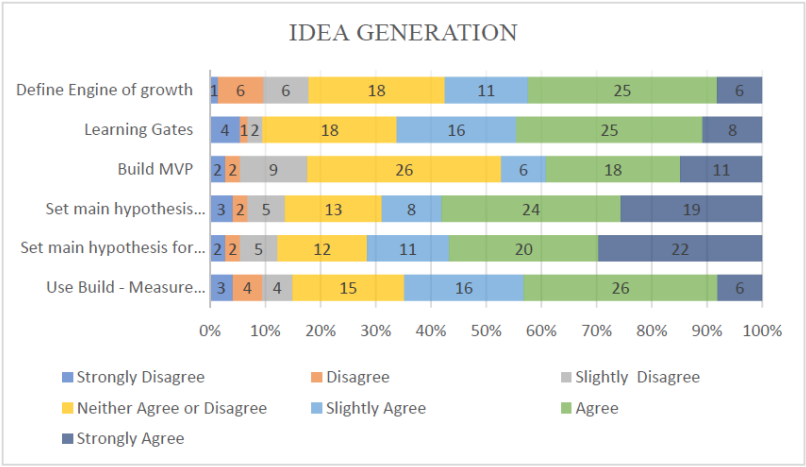
This section focuses on 73 responses. This smaller number of responses has been filtered for the reason the importance of Lean Startup methodology section of the questionnaire was not completed in full (54 respondents). The importance of main activities and tools of the Lean

Startup methodology is shown in Figure 36, 37, 38, 39 and 40 indicating a different pattern of response for each phase.

The survey asked participants to select a position between seven sets of agreements statements for each tool/activity of the Lean Startup methodology enabling respondents to position themselves in the middle between the statements if neither represented their view. On the right side of the questionnaire were demonstrating a greater understanding of the agreement of the use of these tools in product development.

Figure 37 shows the use of these activities and tools during the idea generation phase. The results show several tools and activities are important for this phase, set the main hypothesis for product testing (73% frequently use), set main hypothesis for business (70% frequently use, 14 % seldom or almost never use), learning gates (67%), use Build-Measure-Learn loops (66%) and define engine of growth (57%). This last activity does not make sense, according to Ries (2017) it should be performed in the last phase.

Figure 37 – Use of Lean Startup methodology and tools during the idea generation phase.

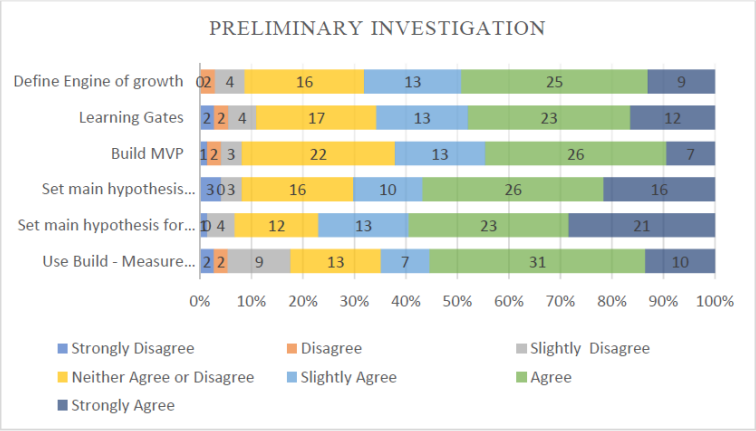


Source: Author (2018).

Figure 38 shows the use of these activities and tools during the preliminary investigation phase. The results also show several tools and activities are important for this phase, set main hypothesis for product

testing (78% frequently use), set the main hypothesis for business (71% frequently use, 8 % seldom or almost never use), learning gates (66%), use Build-Measure- Learn loops (66%), build MVP (63%) and define engine of growth (64%).

Figure 38 – Use of Lean Startup methodology and tools during the preliminary phase.



Source: Author (2018).

Figure 39 shows the use of these activities and tools during the business development phase. The results also show all tools and activities are important for this phase, set the main hypothesis for product testing (73% frequently use), set the main hypothesis for business (71% frequently use), build MVP (70%), define engine of growth (67%), use Build-Measure- Learn loops (66%) and learning gates (64%).

Figure 39 – Use of Lean Startup methodology and tools during the business development phase.

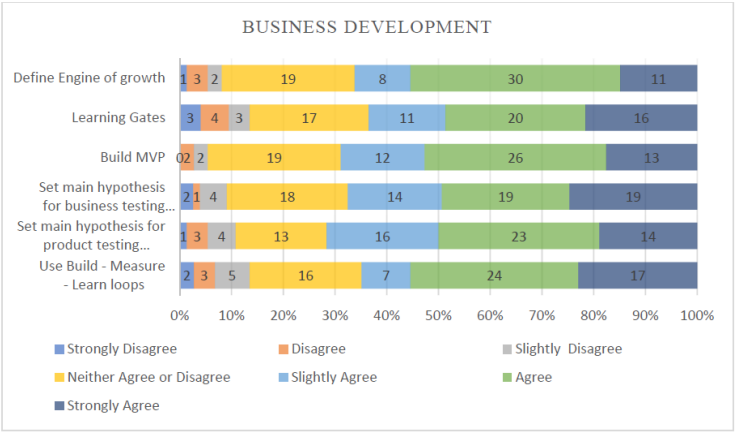
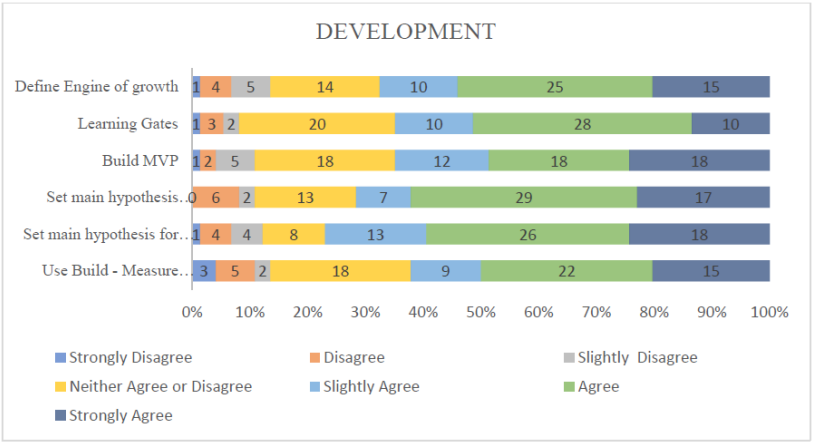


Figure 40 shows the use of these activities and tools during the development phase. The results also show several tools and activities are important for this phase, set the main hypothesis for product testing (78% frequently use), set the main hypothesis for business (73% frequently), define engine of growth (73%), learning gates (66%), build MVP (66%) and use Build-Measure- Learn loops (63%).

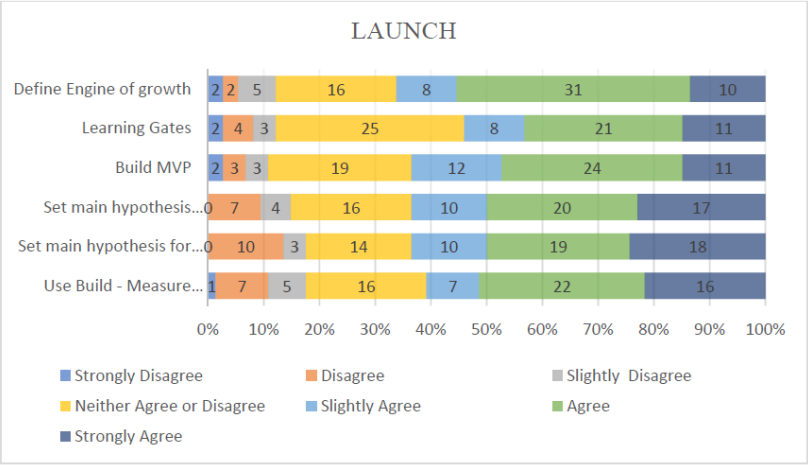
Figure 40 – Use of Lean Startup methodology and tools during the development phase.



Source: Author (2018).

Figure 41 shows the use of these activities and tools during the launch product phase. The results also show several tools and activities are important for this phase, define engine of growth (67%), set the main hypothesis for product testing (64% frequently use), set the main hypothesis for business (64% frequently use), build MVP (64%), learning gates (62%) and use Build-Measure- Learn loops (55%).

Figure 41 – Use of Lean Startup methodology and tools during the launch phase.



Source: Author (2018).

4.2.4.1 Testing for significant relationships and differences

Table 41 and 42 show the results for test-t related to "build-measure-learn-loops" from Lean Startup methodology, where mean and variance are reported considering the variable size of companies: small (less than 1,000 employees) and large (higher than 1,000 employees). A test t was made to determine the significance of the deviation observed between mean values in each phase. This test shows that among the variables considering alpha value at 0.05, all the p-value are higher than 0.05, then there is not a statistically significant difference between the means for small and large company size in each phase.

Table 41 – Results test-t from Use Build-Measure-Learn loops for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.918	4.837	5.081	5.081	4.945	5.459
Variance	1.965	2.584	2.354	2.354	2.774	2.199
Observations	37	37	37	37	37	37
p-value	0.818		1		0.166	

Source: Author (2018).

Table 42 – Results test-t from Use Build-Measure-Learn loops for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	5.054	5.027	5.216	4.864
Variance	2.663	2.915	2.229	3.286
Observations	37	37	37	37
p-value	0.945		0.366	

Source: Author (2018).

Table 43 shows the result for ANOVA test considering all data for small and large size of the company. This test verifies if there are at least two groups statistically different from each other. The result shows that the F-value is lower than the F-critical value for the alpha level selected (0.05). Therefore, we have evidence to accept the null hypothesis and say that all samples have not significantly different means and thus they do not belong to a different population. This means that the respondents believe that this activity can be performed in all phase of product development: idea generation, preliminary investigation, business development, development and launch product phase.

Table 43 – ANOVA: Single factor for BML in all phase

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	3.989	4	0.997	0.396	0.811	2.396
Within groups	919.135	365	2.518			
Total	923.124	369				

Source: Author (2018).

Table 44 and 45 show the results of the set hypothesis for the product at each development phase for different size of the company. Also, the results show there is not a statistically significant difference between the means for small and large company size in each phase.

Table 44 – Results of test-t from set hypothesis for the product for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	5.297	5.459	5.405	5.703	5.189	5.270
Variance	2.215	2.755	2.137	1.381	2.102	1.980
Observations	37	37	37	37	37	37
p-value	0.660		0.338		0.808	

Source: Author (2018).

Table 45 – Results of test-t from set hypothesis for the product for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	5.324	5.486	5.162	4.973
Variance	2.170	2.312	2.473	3.249
Observations	37	37	37	37
p-value	0.643		0.632	

Source: Author (2018).

Table 46 shows the result of ANOVA test for the set hypothesis for the product in all phase. Also, we have evidence to accept the null hypothesis and say that all samples have not significantly different means and thus they do not belong to a different population.

Table 46 – ANOVA: Single factor for the set hypothesis for the product in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	10.145	4	2.536	1.124	0.34458	2.396
Within groups	823.283	365	2.255			
Total	833.429	369				

Source: Author (2018).

Table 47 and 48 show the results of the set hypothesis for business at each development phase for different size of the company. Also, the results show there is not a statistically significant difference between the means for small and large company size in each phase.

Table 47 – Results of test-t from set hypothesis for business for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	5.378	5.189	5.054	5.595	5.162	5.459
Variance	2.131	3.213	2.441	1.803	2.806	1.589
Observations	37	37	37	37	37	37
p-value	0.620		0.115		0.391	

Source: Author (2018).

Table 48 – Results of test-t from set hypothesis for business for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	5.324	5.432	5.108	5.135
Variance	2.225	2.252	1.988	3.065
Observations	37	37	37	37
p-value	0.757		0.942	

Source: Author (2018).

Table 49 shows the result of ANOVA test for the set hypothesis for business in all phase. Also, we have evidence to accept the null hypothesis and say that all samples have not significantly different means and thus they do not belong to a different population.

Table 49 – ANOVA: Single factor for the set hypothesis for business in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	2.783	4	0.695	0.297	0.880	2.397
Within groups	854.419	365	2.341			
Total	857.203	369				

Source: Author (2018).

Table 50 and 51 show the results of build MVP at each development phase for different size of the company. Also, the results show there is not a statistically significant difference between the means for small and large company size in each phase.

Table 50 – Results of test-t from build MVP for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.891	4.621	4.892	5.162	5.243	5.378
Variance	1.821	2.852	1.599	1.750	1.356	1.853
Observations	37	37	37	37	37	37
p-value		0.449		0.372		0.648

Source: Author (2018).

Table 51 – Results of test-t from build MVP for development and product phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	5.027	5.405	4.757	5.351
Variance	1.860	2.470	2.078	2.123
Observations	37	37	37	37
p-value		0.272		0.082

Table 52 shows the result of ANOVA test to build MPV in all phase. Also, we have evidence to accept the null hypothesis and say that all samples have not significantly different means and thus they do not belong to a different population.

Table 52 – ANOVA: Single factor for build MVP in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	13.2864	4	3.321622	1.675169	0.1551	2.396401
Within groups	723.743	365	1.982858			
Total	737.029	369				

Source: Author (2018).

Table 53 and 54 show the results of learning gates at each development phase for different size of the company. Also, the results show there is not a statistically significant difference between the means for small and large company size in each phase.

Table 53 – Results of test-t from learning gates for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	5.162	4.838	4.865	5.243	5.243	4.891
Variance	0.972	3.306	2.009	2.633	2.411	2.988
Observations	37	37	37	37	37	37
p-value	0.343		0.289		0.361	

Source: Author (2018).

Table 54 – Results of test-t from learning gates for idea generation, preliminary investigation and business development phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	5.108	5.189	4.702	5.081
Variance	1.543	2.269	2.048	2.577
Observations	37	37	37	37
p-value	0.801		0.288	

Source: Author (2018).

Table 55 shows the result of ANOVA test for learning gates in all phase. Also, we have evidence to accept the null hypothesis and say that all samples have not significantly different means and thus they do not belong to a different population.

Table 55 – ANOVA: Single factor for learning gates in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	2.665	4	0.666	0.293	0.882	2.396
Within groups	828.945	365	2.271			
Total	831.610	369				

Source: Author (2018).

Table 56 and 57 shows the results of define engine of growth at each development phase for different size of company. Also, the results show there is not a statistically significant difference between the means for small and large company size in each phase.

Table 56 – Results of test-t from define engine of growth for idea generation, preliminary investigation and business development phases.

Phase	Idea generation		Preliminary		Business Dev	
Size	Small	Large	Small	Large	Small	Large
Mean	4.757	4.865	5.108	5	5.135	5.297
Variance	1.633	2.786	1.599	2.222	1.620	2.270
Observations	37	37	37	37	37	37
p-value	0.755		0.738		0.618	

Source: Author (2018).

Table 57 – Results of test-t from define engine of growth for development and product launch phases.

Phase	Development		Launch	
Size	Small	Large	Small	Large
Mean	5.135	5.361	5.027	5.270
Variance	2.064	2.351	2.138	2.147
Observations	37	37	37	37
p-value	0.518		0.477	

Source: Author (2018).

Table 58 shows the result of ANOVA test for define engine of growth in all phase. Also, we have evidence to accept the null hypothesis and say that all samples have not significantly different means and thus they do not belong to a different population.

Table 58 – ANOVA: Single factor for define engine of growth in all phase.

Source of Variation	SS	Df	MS	F	P-value	F critical
Between groups	2.665	4	0.666	0.293	0.882	2.396
Within groups	828.945	365	2.271			
Total	831.610	369				

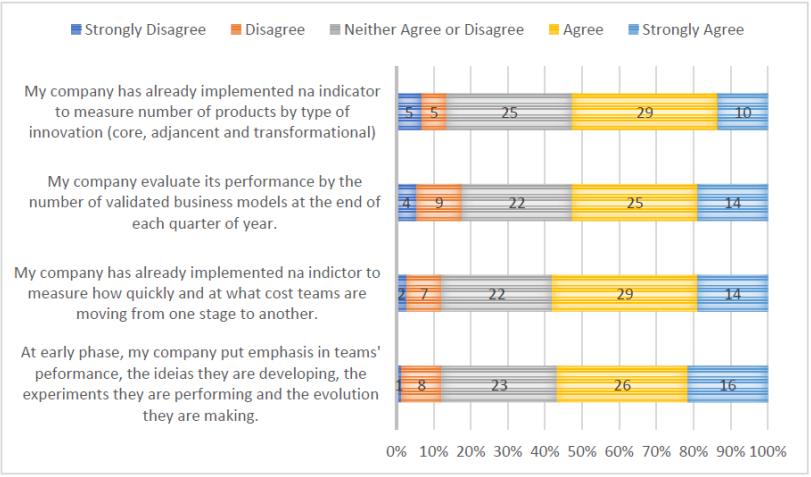
Source: Author (2018).

4.2.5 Key Process Indicators Results

This section focuses on 74 responses. The survey asked participants to select a position between five sets of agreements statements about the key process indicators enabling respondents to position themselves in the middle between the statements if neither represented their view. On the right side of the questionnaire were demonstrating a greater understanding of the agreement of the definition of KPIs in their companies.

Figure 42 shows the results of the respondents regarding how their companies define and measure the product development process. Most respondents agreed (53%) that their company has defined KPI to measure different type of innovation, company has a specific indicator to evaluate number of business models, how much time and investment the team spends during the new developments, and during the initial phase, most company has defined indicators to measure team performance. However, 14% of respondent's answers show that few companies do not implement indicators to measure different product development, validate business model (12%), measure time and costs (12%) and team performance (12%).

Figure 42 – How company defines and measure the product development process.



Source: Author (2018).

4.2.6 Applicability of Stage-gate and Lean Startup Method Results

This section focuses on 73 responses. The survey asked participants to select a position between five sets of agreements statements about the applicability of stage-gate process and Lean Startup methodology enabling respondents to position themselves in the middle between the statements if neither represented their view. On the right side of the questionnaire were demonstrating a greater understanding of the agreement of applicability of these processes in their company.

Table 59 shows the results for the stage-gate process, 53% answered that it can be applied in any size of the project, only 27% agreed applicability in only incremental innovation, 30% agreed applicability in only radical innovation. However, there are almost half of the respondents neither agree or disagree with these statements.

Table 59 – Applicability of stage-gate process.

Statements	SD	D	N	A	SA	T	WA
I believe that the Stage-Gate process can be applied in any kind of project (small, medium and large size)	5.5% 4	5.5% 4	34.2% 25	41.1% 30	13.7% 10	73	3.5
I believe that the Stage-Gate process tools can be only applied in incremental innovation.	9.6% 7	23.3% 17	39.7% 29	15.1% 11	12.3% 9	73	3.0
I believe that the Stage-Gate process can be only applied in radical innovation (complete new product and/or business model)	12.3% 9	15.1% 11	42.5% 31	21.9% 16	8.2% 6	73	3.0
I believe that the Stage-Gate process can be only applied in physical products.	15.1% 11	12.3% 9	45.2% 33	24.7% 18	2.7% 2	73	2.9

Legend: SD (Strongly Disagree), D (Disagree), N (Neutral), A (Agree), SA (Strongly Agree), T (Total) and WA (Weight Average). Source: Author (2018).

Table 60 shows results for applicability of Lean Startup, 54% agreed it can be applied in small, medium and large projects, approximately 40% did not agree it can be only applied in incremental or radical innovations, and only 25% of respondents agreed to use it in only software development.

Table 60 – Applicability of Lean Startup.

Statements	SD	D	N	A	SA	T	WA
I believe that the Lean Startup method can be applied in any kind of project (small, medium and large size)	4.1% 3	9.6 % 7	31.5% 23	32.9% 24	21.9% 16	73	3.6
I believe that the Lean Startup method tools can be only applied in incremental innovation.	15.1% 11	24.7 % 18	34.2% 25	17.8% 13	8.2% 6	73	2.79
I believe that the Lean Startup method can be only applied in radical innovation (complete new product and/or business model)	13.7% 10	28.8 % 21	28.8% 21	21.9% 16	6.8% 5	73	2.79
I believe that the Lean Startup method can be only applied in software products.	17.8% 13	19.2 % 14	38.4% 28	17.8% 13	6.8% 5	73	2.8

Legend: SD (Strongly Disagree), D (Disagree), N (Neutral), A (Agree), SA (Strongly Agree), T (Total) and WA (Weight Average).

Source: Author (2018).

5 DISCUSSION

This section discusses the findings of the self-administrated questionnaire study. It is composed six main parts. The first to fourth item will revisit the objectives of this study as listed in chapter 1 and the research questions defined in chapter 3. The fifth part will review the theoretical framework and the fast part discuss the limitation of the study.

The purpose of this research is to investigate the use of Lean Startup techniques and tools to create innovation in product, service and new business model. The research question is: how companies can incorporate tools and techniques from Lean Startup at each stage of the traditional product development process. Also, the traditional method will be reviewed to focus on the main activities.

The survey was mainly answered by vice presidents, managers or team leaders, 56% work in product development for at least five years, 70% of the total respondents are more than 35 years old. Gender balance in the survey sample is 56% male and 44% female. These characteristics of respondents allow confirming that the answers have good quality information based on their experiences.

The size of the company was analyzed in two categories: small (less than 1,000 employees) and large (more than 1,000). The sample result was approximately equally divided in these categories. This result enables to analysis the survey answer considering the influence of the size of the company. The result for the main segment of companies (65%) was manufacturing, Healthcare, Automotive, Logistics, Construction, Food & Beverages, Telecommunications or Airlines & Aerospace. These features of the survey allow us to understand in general how companies use stage-gate process and tools and Lean Startup methodology during new product development.

5.1 INNOVATION AND STRATEGY FINDINGS

Table 61 is summarized the main findings for strategy and innovation and connect them to the research objective defined in the introduction chapter. Most respondents agree that their company has a digital strategy and use digital technologies (e.g., bid data, technology platforms, mobile products) to create a new product, services, and business. Software increases value to physical products; however, software development frequently has faster cycles than hardware products. The traditional companies need manage their innovation

portfolio and analyze their innovation strategy to accelerate their product development process and put faster their products and services in the market (RINGEL et al., 2018).

This new digital innovation is changing the way companies are creating new products, services, and business model, and it can be the reason why many companies are adapting or creating a new process based on Lean Startup approach.

Table 61 – Research questions and key findings for strategy and innovation.

Research objective	Key findings
Identify if a company included digital innovations in its strategy	• Most respondents (69%) agree that the company has a digital strategy • There is a clear understanding of the impact of digital technologies (75%) • They believe (78%) their company has a clear digital roadmap • 73% answered that their company are good at generating new ideas • 70% have implemented several digital initiatives to improve the products and services • 55% of companies measure innovation indicators
Identify how a company use Startup approach	• 32% of the companies hire products or services from Startups to create new ideas of products • 21% create its own Startup • 19% invest in Startups • 19% of companies which did not implement any Startup initiatives, but they will implement in the future. • 25% of companies with no intention to incorporate Startups approaches in their strategy.

Source: Author (2018).

The second objective is this topic is to identify how a company is using the Startup approach. Most companies (56%) have implemented one or more kind of Startup approach. They are hiring products and services from Startups to generate new products and services ideas. This interface between established companies and Startups was found in the literature (KOHLER, 2016). Some companies are creating their own Startup as shown in the literature, BOSCH established an internal incubator named as Grow focused on radical ideas to develop new, sustainable and profitable business in new markets for Bosch (BOSCH, 2018).

Also, the survey shows that there are companies (44%) which do not have any Startup approach implemented, but 19% of companies are planning to implement it in the next year.

These results are similar from the research conducted by StartSe with 3,900 respondents from established companies about their interests of partnership with start-ups in Brazil, hire products and services from start-ups (20%), create own Startup (20%), participation in incubation/acceleration process of Startups (18%), invest in Startups (12%) and incorporate Startups (11%) (STATISTA, 2018).

5.2 STAGE-GATE AND LEAN STARTUP FINDINGS

The finding for the Stage-gate process was summarized in Table 62. Design thinking approach can complement the Stage-gate process in the idea generation phase. Also, Lean Startup methodology does not have any defined technique for the ideation process. An empirical study showed the applicability of this method in the early phase of new product development in large software companies (EDISON et al., 2018).

The finding for market viability and risk assessments are the same found in literature. In the preliminary phase of new product development is not only fundamental to understand the customers' needs and wants, but also performs other activities. Detailed market studies, preliminary market assessment, preliminary technical assessment, assessing technical feasibility and identifying technical risks, detailed market study, market research, detailed technical assessment – in-depth technical appraisal, establishing proof of concept, business, and financial analysis are important for new product projects and to make investment decision (COOPER, 1994, 2011, 2018).

The respondents for both sizes of the company (small and large) answered that in the development phase is more often used product testing and process testing. These two findings also correspond to literature. The product concept and the benefits to be delivered to the user (including the value proposition) are essential to assure a stable project scope and save time. The product requirements and specifications cannot change throughout the Development stage (COOPER, 1994, 2011, 2018).

The last phase is the launch product phase where it starts the mass production and sales. Then it is not the correct phase to make significant changes in product, service or business. The findings for this phase do not correspond to literature (COOPER, 1994, 2011, 2018).

Table 62 – Research objectives and key findings for stage-gate.

Research objective	Key findings
Identify the more often tools/activities from the Stage-gate process	• More often tools for idea generation: design thinking (57%) and Market viability (59%). • More often tools for preliminary investigation: market viability (60%) and Risk Assessment (57%). • More often tools for business development: product concept testing (55%) and market viability (53%). • More often tools for development: product testing (55%) and process testing (53%). • More often tools for a product launch: product testing (53%) and process testing (51%). • All results for activity/tool versus the size of the company show p-value higher than 0.05, therefore the relationship is not statistical significance. • Business Model testing had p-value lower than 0.05, so there is a statistical significance between this develop a business case variable and the size of the company.

Source: Author (2018).

The finding for Lean Startup was summarized in Table 63. The respondents from small and large companies agree that all tools/activities from Lean Startup methodology can be used in all product development phase. This finding also was confirmed by a study case in large companies. They applied BML loops, learning gates, set hypothesis for product and business during idea generation, development and accelerating phase (EDISON et al., 2018).

However, the finding for define engine of growth can be applied in all phases was opposite from literature review, which defined this activity needs to be performed after to achieve the problem/solution fit in the last phase of the project because its objective is to scale and generate more revenue (EDISON et al., 2018; RIES, 2011).

Table 63 – Research objectives and key findings for Lean Startup.

Research question	Key findings
Identify the importance of Lean-Startup methodology and tools/activities	• Most respondents agree to use set main hypothesis for product testing (73%) and business (70%), learning gates (67%), use BML loops (66%) and define engine of growth (57%) in all phases. • All tools/activities had similar mean for different size of the company (small, large). • No statistical significance between each tool/activity and product development phase (idea generation, preliminary investigation, business development, development, launch product).

Source: Author (2018).

5.3 KEY PROCESS INDICATORS FINDINGS

Most respondents agreed that their company had defined KPI to measure a different type of innovation, the company has a specific indicator to evaluate the number of business models, how much time and investment the team spend during the new developments, and during the initial phase, most company has defined indicators to measure team performance. These finding are a good evidence that these companies are defining better indicators to measure this high-risk project which the objective is to create a new product, services, and business model. The literature also showed that to change the way traditional management measure their innovation is crucial for better evaluate the performance of the Startup team and measure the progress of their projects (VIKI, 2017, p. 104).

However, 14% of respondent's answers show that few companies do not implement indicators to measure different product development, validate business model (12%), measure time and costs (12%) and team performance (12%). This number can be related to the previous finding of types of Startup approach used by companies. Some respondents said their company had no plans to implement it.

5.4 APPLICABILITY FINDINGS

In this part, the findings achieve the objective: Identify the kinds of products or services developed by applying the Lean Startup approach and Stage-gate process in companies.

Most respondents (53%) answered that stage-gate process can be applied in any size of project, only 27% agreed applicability in only incremental innovation, 30% agreed applicability in only radical innovation. Then, these results show different understanding of the use of the Stage-gate process according to the type of innovation. This finding contradicts some authors that said this process is more applicable in incremental innovations (GRIF et al., 2014).

The results for applicability of Lean Startup 54% agreed it can be applied in small, medium and large projects. Also, the respondents (40%) did not agree that the Lean Startup method can be only applied in incremental or radical innovations, it can be applied in any kind of innovation. Another finding is only 25% of respondents agreed to use it in only software development, so this method can be used to develop physical product.

5.5 REVIEW FRAMEWORK

The objective of this item is to achieve the goal: define the combination of Lean Startup methods and stage-gate process for creation of hybrid new product development.

According to the results presented and discussions carried out in previous items, it was reviewed the theoretical hybrid product development framework as shown in Figure 43. In this model was included the main tools/activities of stage-gate found more frequently used and the most important tools/activities of Lean Startup based on results of the survey. These activities are represented by gray fill elements.

This model contains the five phases (idea generation, preliminary analysis, business model development, development and launch product). The Build-Measure-Learn is the central part of this activity is carried out at all stages of development as showed in the results through the flow represented by blue arrows.

A few activities were included without being tested in the survey, but there are a lot cited in the literature review. The go/kill gates from the stage-gate process at the end of each phase.

The general descriptions of the activities evaluated for each phase in this study are:

- Idea generation: design thinking method.
- Preliminary investigation: set the main hypothesis for product, risk assessment, market viability, learning milestones and build MVP.
- Business model development: set the main hypothesis for business and learning milestones.
- Development phase: specify MVP test, build MVP, scope product validation, test process and learning milestones.
- Product launch: define engine of growth, define metrics and launch manufacturing test.

The hybrid model begins with idea generation phase. The team searches for new product ideas and business ideas through the activity Design Thinking process. This activity contains the definition of the problem, evaluating several options, tightening the field, and choose the best ideas. Another source of insights for products is the interaction with customers. The second activity can be performed through using Voice of Customer to discover unspoken needs and customer problems. The third activity is to map the changes and tends socio-economics such as digital technologies (e.g., big data, internet of things, mobile applications.).

All ideas discovered are stored in a Database. The manager should make decision during the decision gate regard which idea will be selected to develop. This decision should be based on company strategy and its portfolio goals.

The next phase, preliminary investigation, starts with idea selected and initial budget approved. The team defines the main hypothesis for product, performs preliminary risk assessment and market viability. The information collected should be evaluated. The results of this analysis should be discussed in the learning milestones, which allows to continue the development and build the prototype or return to previous activities to improve the information about product, business or customer.

At the end of preliminary investigation has a decision gate, which approves the project to continue the development in the next phase or reject the project to define better the product.

In the earlier phases, it is fundamental to measure the team performance, the number of hypotheses defined, tested and valeted for product and business (actionable indicators).

The business model development begins with the definition of the main hypothesis for business model. The team should test the business model through channels, customer relationship and key partners. The team analysis the outputs in the learning milestone. This milestone allows to continue the development through define costs, revenue models and build the business case based on evidence and data. Also, the learning milestone allows to perform the B-M-L loops if is necessary to refine the business model.

The decision gate in the business model development phase approve or reprove the project for next phase. The managers should decide about investment and team allocation.

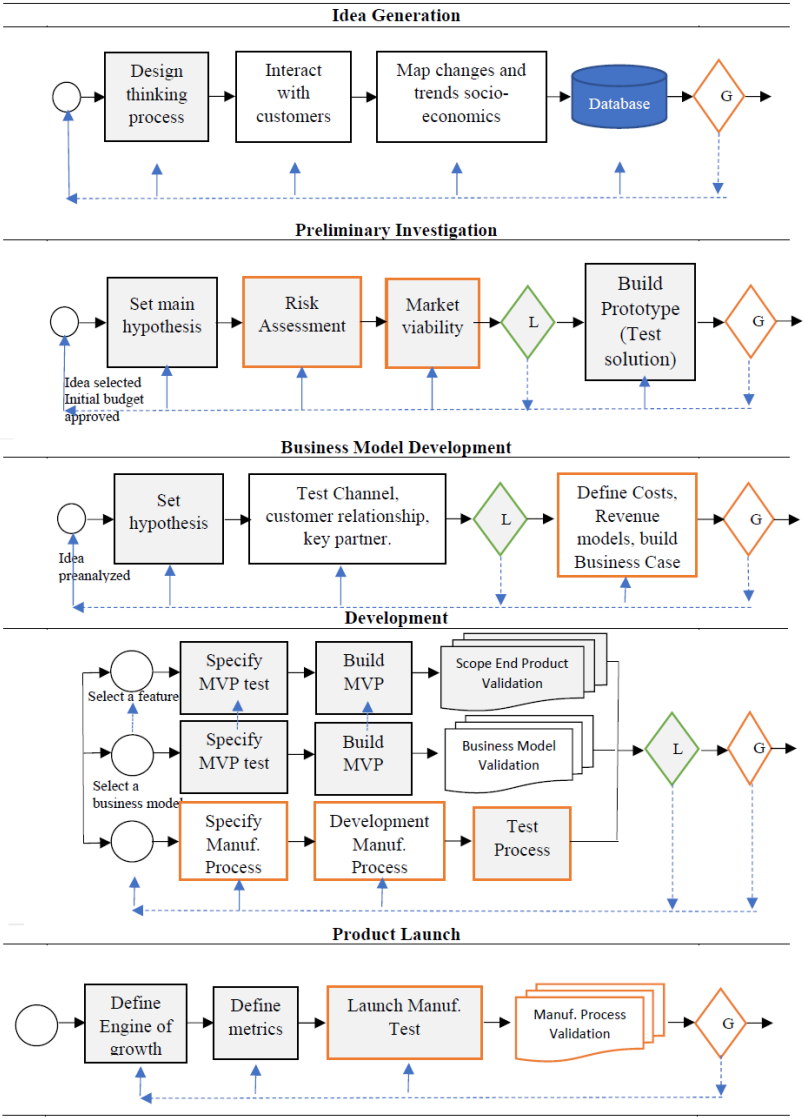
The development phase should close and validate the scope product and business model. Also, it should specify and test the manufacturing process. This phase starts with the selection of the features for product and business. These characteristics supports to specify the test and build the minimum viable product (MVP). The team should finish the scope of the final product and business model.

The learning milestones is performed by team and leaders (e.g., manufacturing, research & development, quality, marketing). This milestone allows to evaluate and refine the information before the decision gate. The final gate (go/kill) is composed by top managers and directs from several departments such as manufacturing, research & development, quality, marketing.

The last phase, product launch, begins with the definition of engine of growth. The team should choose how the product will increase the revenue. The Lean Startup methodology suggests some ways how to scale innovative products. The team can evaluate the customer retention, perform marketing through word-of-mouth and focus on paid marketing, advertising or a sales force to promote the growth of the product. Also, it should define the metrics how to measure the different products maturity levels to avoid premature scaling.

The manufacturing test and validation should be finished in the last phase of the product development. The managers and directors should evaluate if the project could be closed or not.

Figure 43 – Review of the theoretical framework.



Source: Author (2018).

6 CONCLUSION

This chapter answers the research questions formulated in this dissertation and discusses the implications of the findings. It also discusses the limitations of this study, and it suggests some ideas for future research.

6.1 IMPLICATIONS OF FINDINGS FOR NEW PRODUCT DEVELOPMENT PROCESS

This dissertation presented a quantitative survey on companies related to digital innovation, types of Startup approaches adopted by companies, more often use of the tools and activities of the Stage-gate process and the Lean Startup method. Also, it studied the key process indicators and applicability of the LS and Stage-gate. In this way, there are seven main contributions of this study for the new product development process.

First, strategy and digital innovation are driving new product development and creating new business models. This study identified that companies are including digital innovations in their strategy. Most respondents (65%) agree that the company has a digital strategy and 75% said that the company has a clear understanding of the impact of digital technologies and a digital roadmap. Also, 70% answered that the company already had implemented several digital initiatives to improve the products and services and companies have indicators to measure innovations.

This result about digital strategy and innovation confirms the findings in the literature, in a survey of 100 Europeans companies, many respondents (79%) also agreed that their companies know how business is changing due to digitalization and establish a clear digital roadmap to accomplish the company objectives (LEADER, 2016). Also, the literature showed that traditional established companies such as BMW transformed into a digital platform called BMW Connected and Daimler Benz developed carsharing services for 2.4 million members by applying internet connectivity and smartphone applications (MÄLKKI; STAFFA, 2018).

In conclusion, traditional companies are pursuing digital technologies to expand their portfolios and they need a new methodology to create new product and new business. Established companies are

making a partnership with Startups to create new products, services and business for themselves.

The second objective of this study identified how a company uses Startup approach. Most respondents (56%) answered that their company has already implemented one or more type of Startup approach: 32% of the companies hire products or services from startups to create new ideas of products, 21% create its own Startup and 19% invest in Startups.

The findings of Startup approach by companies was the same in the literature review (STATISTA, 2018). This new approach of the companies associated with digital innovation (e.g., Bid Data, Mobile applications) can be the reason for the emergence of a new product development process such as the Lean Startup method. The new products and services are related to digital innovation. The software is increasing value to physical products, and digital technologies enable idea generation and exploration.

However, the development of software frequently happens in faster cycles than physical products, creating new challenges for innovation in established companies using the traditional product development process (i.e., Stage-gate process). These companies need to accelerate innovation. Digital innovation is the source of new insights about customer trends, and the Lean Startup method can be the way to develop faster new products and business models.

The third objective identified the more often tools and activities of the Stage-gate process for each product development phase. This study found that the design thinking process (57% of the respondents) and market viability (59%) is frequently used in the idea generation phase. The risk assessment (57%) is used in the preliminary investigation phase. The product (55%) and process testing (53%) is used in the development phase.

The statistical test ANOVA verified there is no difference to use a specific activity or tools from the Stage-gate process in a specific development phase. All tools and activities studied can be used in all phases. This result is not supported by the literature of the Stage-gate process which defines the necessity to perform certain activities in specific development phase (COOPER, 2011, 2018; SERGIO et al., 2015).

Most research on the Lean Startup approach is focused on new and emerging software Startups, the high-tech companies, there is a lack of empirical research examining its implementation in established companies. The fourth objective identified the more often tools and activities of the Lean Startup method, and where these tools can be

applied in product development phases. The statistical test t verified that there are no differences between tools and activities for both development phases and the size of the company (small, large). All tools and activities studied can be applied in any size of the organization.

The same result for ANOVA test was found for the Lean Startup. There is no statistical significance to using one activity in a specific development phase. This result is according to literature because the Build-Measure-Learn loops can be used in all stages, from idea generation to launch phase. It is a core activity of the Lean Startup. The fundamental idea is to perform fast cycles based on product and business hypothesis, test them and quickly learn directly from customers feedbacks (RIES, 2011, 2017).

Lean Startup method and Stage-Gate do not have an explicit initial phase for idea generations. Some authors recommended the Design Thinking method for this phase (MUELLER; THORING, 2012). In this study is confirmed the applicability of this method in the idea generation phase.

The fifth objective identified that most companies had defined key process indicators to measure different type of innovation, for example, companies have established an indicator to evaluate the number of business models and how much time and investment the teams spend during the product development phases. Also, it was identified that some companies have indicators to measure the team performances, especially in the early phase when they are discovering new ideas for products, services, and business models.

The sixth objective of this study identified the kinds of products or services developed by applying the Lean Startup method and Stage-gate process in companies. We found that the most respondents (54.8%) agreed that Stage-gate process can be used in any size of the project (small, medium, large) and only 30% respondents agreed that it can be used in incremental innovation and 30% agreed that this process only can be used in radical innovation.

These results showed that some companies use this process to make improvements in current products and other companies use for radical innovation. This finding contradicts some author found in the literature. They argued that the traditional Stage-gate process has a lot of phases and activities and it is not adequate for radical innovations (GRIF et al., 2014; SERGIO et al., 2015).

In addition, there are few innovation processes identified in the literature, but they not investigated the combination of Lean-Startup and Stage-gate process. However, this study is one of the first attempts to fill

these gaps. The last objective of this research drew a hybrid framework with selected tools and activities based on survey answers.

This model enables companies to develop a new product, services, and business models by applying phases, decision gates, Design Thinking, Risk Assessment, Market Viability, Product and Process testing from the Stage-gate process. This model added from the Lean Startup method the Build-Measure-Learn loops to be used in all phases. Also, the scientific testing approach by setting main hypotheses for product and business and build a minimum viable product to test these hypotheses directly with the customers.

6.2 LIMITATIONS OF THE STUDY

The approach we took in this study contains some limitations. The data collection method selected, self-administrated questionnaire, by itself has some restrictions. The respondent needs to comprehend what is being asked, they need to judge whether the question is about behaviors or opinions and they need to access their memory with a series of judgment and estimation processes. Also, if a set of offered options are not the result of those steps, the respondents will choose a response option by mapping what is in their heads among the options offered. Also, considering the size of the entire population, the number of answers in the survey might be not enough to identify all key tools/activities for Stage-gate and Lean-Startup.

Also, this study does not include all the tools and activities from the Lean Startup and the Stage-gate process that are in the hybrid product development framework because of the limitation of the size of the questionnaire. The respondents answered the survey an average of 11 minutes.

However, we examined the available source to achieve data, including in literature review several examples of companies applying Lean Startup in their product development. In this study, we have achieved a better understanding of Lean Startup as a potential methodology that enables product innovation in established companies.

6.3 RECOMMENDATION FOR FUTURE RESEARCH

We have some suggestion to address the limitations of the research approach used in this study. The first suggestion is to select a sample by country or type of industry to increase the number of the

answer in the survey. A future study could apply a different research method such as interviews and study cases in established companies to identify the main tools/activities of the Lean Startup approach in the context of established companies.

The second direction of future research could perform a quantitative study to investigate the impact of Lean Startups on the success of product innovation in established companies. Several metrics have been suggested to measure the success of innovation in the context of large companies such as the perceptual of revenue generated by the new product. This study could statistically support the cause-effect relationship between Lean Startups method and new product development.

In the digital era, companies need to create fast new product, service and business model. Lean Startup has demonstrated a useful method for the new product development process. However, as digital technologies evolve fast cycles of development, it should be studied agile methods with NPD and Lean Startup method and tools.

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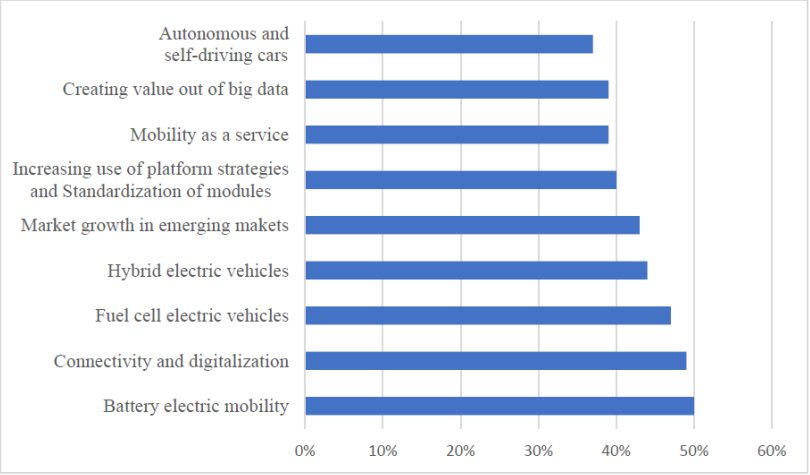
APPENDIX A – Additional Literature Review

The automotive industry is recognized in the world to be the most predominant and innovative brands, however its highly competitive demands high research and development spending. A survey showed that the main trend of automobile innovation is connectivity and digitalization (MÄLKKI; STAFFA, 2018).

Figure 44 – The main tendency of automobile innovation until 2025.



Source: (MÄLKKI; STAFFA, 2018).

APPENDIX B – Introducing a self-administered research

The following scientific survey aim to record data about New Product Development and Lean Startup Method as part of Clarice Chagas' master thesis at University Federal of Santa Catarina (Brazil) and University of Applied Sciences Ingolstadt (Germany).

ALL THE INFORMATION YOU PROVIDE WILL BE TREATED IN THE STRICTEST CONFIDENCE.

The questionnaire should take you about ten minutes to complete. This survey is being carried out to find out how you feel about traditional stage-gate process and Lean startup method. Even if you feel the items covered may not apply directly to your work, please do not ignore them.

If you have any queries or would like further information about this master research, please email me on clu4934@thi.de

Thank you for participating in our survey. Your feedback is important.

APPENDIX C – Questionnaire

Section A – General Questions

Question 1: What is your age? (List question, attribute variable)
Question 2: What is your full job title? (List question, attribute variable)
Question 3: Which department do you work? (List question, attribute variable)
Question 4: How many years have you been working in product development? (category question, attribute variable)

i. Less than 1 year
ii. At least 1 year but less than 3 years
iii. At least 3 years but less than 5 years
iv. At least 5 years but less than 10 years
v. 10 years or more

Question 5: What is your gender? (List question, attribute variable)
Question 6: Which country do you currently work? (List question, attribute variable)
Question 7: How many employees work at your company? (category question, attribute variable)

i. More than 100,000
ii. 50,000 - 100,000
iii. 10,000 - 50,000
iv. 1,000 - 10,000
v. 100 - 1,000
vi. Less than 100

Question 8: Which of the following best describes the principal industry of your company? (List question, attribute variable)

i. Advertising & Marketing
ii. Agriculture
iii. Airlines & Aerospace (including Defense)
iv. Automotive
v. Business Support & Logistics
vi. Construction, Machinery, and Homes
vii. Education
viii. Entertainment & Leisure
ix. Finance & Financial Services
x. Food & Beverages
xi. Government
xii. Healthcare & Pharmaceuticals
xiii. Insurance

xiv. Manufacturing
xv. Nonprofit
xvi. Retail & Consumer Durables
xvii. Real Estate
xviii. Telecommunications, Technology, Internet & Electronics
xix. Transportation & Delivery
xx. Utilities, Energy, and Extraction

Question 9: What do you feel about your company' vision and tactical strategy to implant digital innovation (e.g., big data analytics, speed of adopting new technologies, mobile products, digital design, Internet of Things) across the organization?

Statements	SD	SwD	N	SwA	SA
There is an inspiring vision of how digital can create a new future with shared value for my organization.					
My organization has a clear understanding of how the competitive landscape is changing due to digital trends.					
We have a clear roadmap to use digital to help us deliver our business objectives					

Legend: Strongly Disagree (SD), Somewhat Disagree (SwD), Nether agree nor disagree (N), Somewhat Agree (SwA) and Strongly Agree (SA).

Question 10: What do you feel about how your company use digital technologies to create products and services?

Statements	SD	SwD	N	SwA	SA
My company is good at generating and implementing new ideas to improve performance					
My company has already successfully implemented several digital initiatives that improve or adapt its products and services					
There are well-defined metrics to measure the impact of each innovation on my company' bottom line.					

Legend: Strongly Disagree (SD), Somewhat Disagree (SwD), Nether agree nor disagree (N), Somewhat Agree (SwA) and Strongly Agree (SA).

Question 11: Please, mark one or more options to answer the question: My organization has already implemented several startup approaches that create or improve its products and services, for example:

	hires products and services from startups generating and implementing new ideas to improve performance offer products and services to the market.
	create own Startup.
	participate in incubation/acceleration process of start-ups
	invest in start-ups
	acquire and incorporate startups
	did **not** implement any startup approach, but it will implement startup initiatives next years.
	did **not** implement any startup approach, but it will **not** implement startup initiatives next years.

Section B – Use of New Product Development Tools

Question 12: Please indicate whether each activities/tools of stage-gate process are used in product development and at which stages.
1 (Never), 2 (Almost never), 3 (Seldom), 4 (Sometimes), 5 (Frequently), 6 (Almost all the time), 7 (All the time).
I believe this tool or activity is used in product development process at…

Activity/Tool	Idea generation	Preliminary Investigation	Business and market analysis
Design thinking process	1 to 7	1 to 7	1 to 7
Interact with customers	1 to 7	1 to 7	1 to 7
Map changes and trends socio-economics	1 to 7	1 to 7	1 to 7
Risk Assessment	1 to 7	1 to 7	1 to 7
Market viability	1 to 7	1 to 7	1 to 7
Develop a Business Case	1 to 7	1 to 7	1 to 7
Product concept testing	1 to 7	1 to 7	1 to 7
Business Model testing	1 to 7	1 to 7	1 to 7
Process testing	1 to 7	1 to 7	1 to 7
Define Costs	1 to 7	1 to 7	1 to 7
Define Revenue models	1 to 7	1 to 7	1 to 7
Gates to approve the phase	1 to 7	1 to 7	1 to 7

Activity/Tool	Product development	Product launching
Design thinking process	1 to 7	1 to 7
Interact with customers	1 to 7	1 to 7
Map changes and trends socio-economics	1 to 7	1 to 7
Risk Assessment	1 to 7	1 to 7
Market viability	1 to 7	1 to 7
Develop a Business Case	1 to 7	1 to 7
Product concept testing	1 to 7	1 to 7
Business Model testing	1 to 7	1 to 7
Process testing	1 to 7	1 to 7
Define Costs	1 to 7	1 to 7
Define Revenue models	1 to 7	1 to 7
Gates to approve the phase	1 to 7	1 to 7

Section C – Importance of Lean Startup Methods and Tools

Question 13: Please indicate whether each Lean Startup tool and method is important in product development in each stage.

1 (Strongly disagree), 2 (Disagree), 3 (Slightly disagree), 4 (Neither agree nor disagree), 5 (Slightly agree), 6 (Agree), 7 (Strongly agree).

I believe this tool or activity is important to product development process at…

Tool or Activity	Idea generation	Preliminary Investigation	Business and market analysis
Use Build – Measure – Learn loops	1 to 7	1 to 7	1 to 7
Set main hypothesis for **product** testing based on customer needs.	1 to 7	1 to 7	1 to 7
Set main hypothesis for **business** testing based on customer needs.	1 to 7	1 to 7	1 to 7
Build MVP	1 to 7	1 to 7	1 to 7
Learning Gates	1 to 7	1 to 7	1 to 7
Define Engine of growth	1 to 7	1 to 7	1 to 7

Tool or Activity	Product development	Product launching
Use Build – Measure – Learn loops	1 to 7	1 to 7
Set main hypothesis for **product** testing based on customer needs.	1 to 7	1 to 7
Set main hypothesis for **business** testing based on customer needs.	1 to 7	1 to 7
Build MVP	1 to 7	1 to 7
Learning Gates	1 to 7	1 to 7
Define Engine of growth	1 to 7	1 to 7

Question14: What do you feel about how your company define and measure new products, services and business development process?

Statements	SD	SwD	N	SwA	SA
At early phase, my company put emphasis in teams' performance, the ideas they are developing, the experiments they are performing and the evolution they are making.					
My company has already implemented an indicator to measure how quickly and at what cost teams are moving from one stage to another.					
My company evaluate its performance by the number of validated business models at the end of each quarter or year.					
My company has already implemented an indicator to measure number of products by type of innovation (i.e. core, adjacent and transformational).					

Legend: Strongly Disagree (SD), Somewhat Disagree (SwD), Nether agree nor disagree (N), Somewhat Agree (SwA) and Strongly Agree (SA).

Section D – Applicability

Question 15: For the following statements about applicability of stage-gate process please select the option that matches your view most closely.

Statements	SD	D	N	A	SA
I believe that Stage-Gate process can be applied in any size of project (small, medium and large size)					
I believe that Stage-Gate process tools can be only applied in incremental innovation.					
I believe that Stage-Gate process can be only applied in radical innovation					

(complete new product and/or business model)					
I believe that Stage-Gate process can be only applied in physical products					

Legend: Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A) and Strongly Agree (SA).

Question 16: For the following statements about applicability of Lean Startup method please select the option that matches your view most closely.

Statements	SD	D	N	A	SA
I believe that Lean Startup method can be applied in any size of project (small, medium and large size)					
I believe that Lean Startup method can be only applied in incremental innovation.					
I believe that Lean Startup method can be only applied in radical innovation (complete new product and/or business model)					
I believe that Lean Startup method can be only applied in software projects.					

Legend: Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A) and Strongly Agree (SA).