Applying Lean Startup Methods in Traditional Manufacturing Firms: A Theoretical Perspective

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Abstract

The Lean startup methodology is a new method to build a sustainable business, focusing on central issues such as customer feedback, iterative cycles, and minimum viable products. For startup ventures this method proved fruitful and multiple startups have already successfully implemented this methodology. This literature-based research aims to identify the possibility to extend the scope of this methodology and apply typical facets of the lean startup method in new product development processes of well-established firms in order to improve performance. A systematic literature review is conducted in order to identify typical facets of the lean startup methodology after which facets of new product development processes were highlighted. Consequently a comparison is made and a conclusion drawn based upon the findings. The results show promising results to apply the more elaborate facets of the lean startup methodology in new product development and a potential to improve performance in established firms but certain challenges should be taken into account since startups are composed differently than established firms.

Lean Startup, New Product Development, Lean methodology, Lean Product Development

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1. INTRODUCTION

The lean startup methodology originates from the software industry. Software startups were faced with a highly challenging, volatile industry (Björk, Ljungblad, & Bosch, 2013). Nevertheless, the Lean Startup methodology enabled them to achieve great results, such as "greater market satisfaction, deeper customer engagement, earlier discovery of hidden market opportunities, higher revenues and more efficient resource utilization" (Benefield & Greening, 2013, p. 4834). Currently the Lean Startup methodology is used in various industries (Ries, 2011).

There are signs that the lean-startup methodology is not just a solution for young startups. During the past years departments of large companies like General Electric, Qualcomm and Intuit, have begun to use the lean startup methodology when developing new products. The lean startup approach may help these corporations ass well to meet the pressure of rapid change and innovate swiftly. These are important factors for large companies because corporations need to keep inventing new business models to ensure their survival and growth (Blank, 2013).

In light of the potential impact of the lean methodology on both start-ups and large firms, the focus of this research will be on typical facets of the lean start-up methodology (I), typical features of new product development in large firms (II), and the possibility of applying facets of the lean start-up methodology in new product development (III)

Key Concepts

Lean start-up methodology: A scientific approach to creating and managing start-ups that focuses on iterative learning, customer feedback, and experimentation.

New Product Development (NPD): Turning an idea into a product.

Lean Product Development (Lean PD): "Lean product development is continuous, value-focused product development" (Khan, et al., 2011, p. 1110).

Minimum viable product (MVP): A product containing only critical features that is used to gather feedback from customers, after which it may be revised. The minimum viable product is the version of a new product which allows a team to collect the maximum amount of learning about customers with the least effort (Ries, 2009)

Validated learning: A method to develop a sustainable business, a philosophy of the lean startup methodology. (Ries, 2011)

1.1. Research Goal

"Identifying significant facets of the lean methodology and ascertaining whether they can be applied in new product development processes of established firms"

1.2. Research question

The central research question will be: *"What facets of the lean start-up methodology can be applied in new product development processes of established firms"*

In order to answer this question we break it down into two sub questions, namely:

Sub question 1: *"What are typical facets of the lean start-up methodology?"*
Sub question 2: *"What are typical features of new product development processes in established firms?"*
Sub question 3: "*Can the lean start-up facets be applied in new product development processes in order to improve performance?"*

2. THEORETICAL FRAMEWORK

Nerur and Balijepally (2007) claim that learning and innovation are gradually preferred above the conventional objective of optimizing processes and control: "Emerging practices like agile development question the assumption that change and uncertainty can be controlled through a high degree of formalization" (Nerur & Balijepally, 2007, p. 78), suggesting that the time of designing products up front has been. While focusing on methodologies using innovation and learning, the 'lean methodology' is the most relevant practice in this paper.

In manufacturing firms, the lean method is an upcoming trend as well since the last decade of the 20th century (Gunasekaran, 1999, p. 102). Other literature also addresses the upcoming process of 'lean product development' (Ward & Sobek II, 2014), which is adapted from lean manufacturing and applied to product development (Khan, et al., 2011).

Maurya (2012) wrote a book called 'Running Lean' which builds upon the lean startup methodology of Ries. My research will build upon those two books together with other relevant literature.

The lean methodology is "a systematic process for iterating from Plan A to a plan that works, before running out of resources" (Maurya, 2012, p. 13). The methodology offers a better method through which new ideas and products can be tested. The lean methodology is described as:

- Lean is about speed, learning, and focus
- Lean is about testing a vision by measuring how customers behave
- Lean is about engaging customers throughout the product development cycle
- Lean tackles both product and market validation in parallel using short iterations
- Lean is a disciplined and rigorous process

Source: (Maurya, 2012, p. 14)

Furthermore, one of the most important lean Start-up techniques is the minimum viable product (MVP) which is not about creating a minimal product. It is about obtaining a maximum amount of validated learning with the least amount of possible effort (Ries, 2009). The same Eric Ries, inventor of the term 'Lean Start-up', also claims that the Lean Start-up approach can work in any size and industry, and that Start-ups are founded to build a sustainable business by validated learning (Ries, 2011). These statements provide a framework in which this research can be carried out, focusing on the lean startup methodology and new product development.

3. STRUCTURE OF THE RESEARCH

After mapping typical facets accountable for the success of the lean start-up, consequently, literature will be analyzed what typical facets in the new product development process are. Then, in a subsequent section an analysis will be done if the lean start-up facets can be applied in the new product development process. A detailed comparison of the two processes could provide a better understanding. The key concepts described in the former section will form the focus of the literature search.

3.1. Academic and practical relevance

This research builds upon literature regarding the lean methodology. Most papers and books focus upon the lean methodology in start-up ventures, while the application of lean principles in new product development processes of established firms has received significantly less attention. This research is relevant because it shows whether the lean approach in start-ups offers benefits for NPD processes of established firms, increasing their potential for sustainable competitive advantage.

Since the lean start-up is a proven method when used in new start-up ventures potential advantages await for NPD processes. Among those advantages may be reduced uncertainty and less waste when developing new products.

4. METHOD

The research methodology of this thesis is a systemic literature review (SLR). To conduct a comprehensive SLR the author used the methodology of Moody (2009), which consists of five steps. His methodology guarantees a strict and complete overview, but is also highly time consuming. Since this is a bachelor thesis, there is not enough time to use the full version of Moody's method. Therefore, the author has chosen to deviate from this exhaustive approach at a selection of the steps. In table one the step, original approach, and deviation to fit the bachelor thesis are shown. To make sure all relevant literature is covered an additional approach is taken by the author, using forward or backward citation analysis on the papers approved on the basis of the abstract review.

	Step	Original approach	Deviation
1	Clearly defined (and justified) choice of search engines.	Cover the top 25 journals based on rankings in the relevant area with search engine, guarantee 100% coverage. Hand search the journals not covered.	Top 25 journals should be covered at least 80%. Journals not covered by the search engine will not be hand searched.
2	Clearly defined (and justified) choice of keywords	Search a topic using all synonyms, word forms, and different spelling. E.g.: by using (*) and (?)	No deviation
3	Clearly defined selection criteria	Use inclusion and exclusion criteria and apply them by searching titles and abstracts to filter irrelevant literature	Avoid discovering too many studies by using very precise formulation
4	Clearly defined prioritization criteria	Focus on quality instead of quantity. Search for top journal rankings or citation criteria	No deviation
5	Evaluation and synthesis of papers, not just sequential description.	Describe the content of the literature and address which papers concur and which disagree, take into account the strength of evidence.	No deviation

Systematic literature review method (Moody, 2009)

The journal ranking that is used in step 1 of this SLR to ensure coverage of top journals dates from 2012 (Thonpapani, 2012) and ranks the relevant journals in the field of technology and innovation management. The ranking includes - based on two different citation analyses - the period 1997-2001 and the period 2006-2010. For this research the most recent ranking (2006-2010) will be used (see appendix 1). The rankings address the top 25 journals in technology and innovation management. Search engine Scopus covers 100% of the top 10 of these journals and 92% of the top 25 journals which is well within the range for this thesis.

Since this study aims to check the feasibility of lean startup principles in new product development processes two shifts of search will be carried out, addressing both terms.

At first the term 'lean start*up' was entered, yielding 92 results. Consequently inclusion criteria were added. Inclusion criteria are criteria used to include prospective literature in the subsequent step in the search process, filtering out the articles which did not regard 'lean', 'lean startup', or 'startup companies' in the keywords resulting in 25 papers. Abstract review was conducted on all 25 papers, leaving six relevant ones, and subjected to backward citation analysis resulting in a total of 22 articles.

What	Activity (in Scopus)	Results (# articles)
Search Term in search bar	'Lean start*up'	92
Inclusion criterion: 'limit search to'	Keywords 'lean', 'lean startup' 'startup companies'	25
Abstract review	Disqualify irrelevant articles	6
Backward citation analysis	Add additional relevant literature	22

*Search process for 'lean start*up'*

Secondly, the term 'new AND product AND development' was entered, yielding 94,829 results, after which articles not including 'new product development' were excluded leading to 2,833 results. Because of the vast amount of results the author decided to include 'stage gate' into the criteria for it is one of the most important concepts in the NPD process. This lead to 233 results. Prioritization criteria were used, limiting the search to journal published articles, resulting in 168 results. The next step was to limit the search to the subject area of 'business management and accounting' resulting in 138 hits. After ordering the results on 'relevance' (sorting the results according to the best match of the search terms in Scopus) the author decided to subject the top 20 to abstract review. 11 remained relevant. Finally backward citation analysis is conducted to identify more relevant papers not fulfilling the initial inclusion criteria.

What	Activity (in Scopus)	Results (# articles)
Search Term in search bar	'new AND product AND development'	94,829
Inclusion criterion: 'limit search to'	'new product development'	2,833
Search Term in search bar	'Stage Gate'	233
Prioritization criterion: 'limit search to'	Source type: Journals	168
Inclusion criterion: 'limit search to'	Subject area: Business Management and Accounting	138
Prioritization criterion: Rank on relevance	Top 20 journals based on relevance	20
Abstract review	Disqualify irrelevant journals	11
Backward citation analysis	Add additional relevant literature	18

Search process for 'new product development'

Although having treated both significant search terms separately, a synthesized term was added in order to improve the extensiveness of this literature review. Thus the author searched on the term 'lean product development' adjacent to 'new product development' as well as 'lean startup. After the initial 141 results, a prioritization criterion was added to limit the search to journals, yielding 56 hits. After ordering on relevance once more, the top 20 journals were subjected to abstract based review. 12 articles remained relevant subjecting those to backward citing analysis resulting in 24 useful articles.

What	Activity (in Scopus)	Results (# articles)
Search Term in search bar	'lean AND product development'	141
Prioritization criterion: 'limit search to'	Source type: Journals	56
Prioritization criterion: Rank on relevance	Top 20 journals based on relevance	20
Abstract review	Disqualify irrelevant journals	12
Backward citation analysis	Add additional relevant literature	24

Search process for 'lean product development'

5. THE LEAN START-UP METHODOLOGY (LSM)

The lean start-up methodology was developed by Eric Ries (2011). Sourcing industries and processes like lean manufacturing were studied. This application formed the initial work of a methodology which in turn lead to a book called 'The Lean Startup' (Ries, 2011). Ries describes five principles upon which The Lean Start-up is built. These cornerstones are of paramount importance, providing a guideline needed to implement the Lean methodology and are according to this methodology the basis of lean thinking.

- Entrepreneurs are everywhere – The lean start-up approach can work in every size company.
- Entrepreneurship is management – A start-up is an institution, not just a product, it requires management.
- Validated learning – Start-ups do not exist to 'make stuff', but they exist to 'learn how to build a sustainable business'. This learning can be validated by applying the scientific method.
- Build-Measure-Learn – Fundamental to the activity of the start-up is to turn ideas into products, measure how customers respond and then learn whether to persevere or pivot.
- Innovation accounting – Focus on the boring stuff: how to measure progress, how to set up milestones, and how to prioritize work.
  Source: (Ries, The Lean Startup, 2011, pp. 8-9)

These principles cover an array of aspects implying flexibility and a customer oriented attitude is important when applying the lean startup methodology.

In order to assess the important facets of the Lean Start-up Methodology, the scientific studies identified in the first shift of the SLR have been analyzed. The literature brought forth seven significant facets of the LSM, shown below, which will be elaborated on in the following section.

	MVP	Lean Canvas	BML	Pivoting	Validated Learning	Engine of Growth	Customer Development
Blank (2006)							X
Blank (2013)	X			X			X
(Mueller & Thoring, 2012)	X		X	X			X
(Ries, 2011)	X		X	X	X	X	X
(Maurya, 2012)	X	X	X	X	X	X	X
(Bosch et al., 2013)	X		X	X	X		X
(Moogk, 2012)	X					X	

Concept matrix Lean Startup Methodology

5.1 Minimum Viable Product (MVP)

According to Blank (2013), A lean start-up produces a 'minimum viable product' which allows for 'quick, responsive development'. It only comprises the critical features of the product. An iterative cycle is passed in which products are manufactured and tested with customers, after which feedback is gathered. After processing this feedback the cycle starts at its initial phase (Blank, 2013).

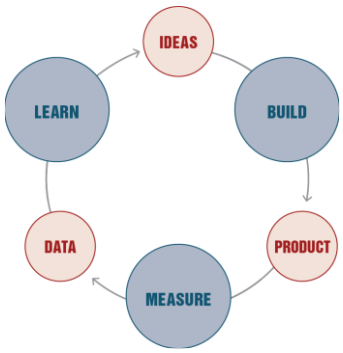
A similar approach is adopted by Ries (2009), coining the term MVP in his book The Lean Start-up, as a version of the product that can start the process of learning and using the Build-Measure-Learn feedback loop (see section 5.2). Furthermore, Ries states that the MVP allows entrepreneurs to start the process of learning as quickly as possible with the goal of testing important business assumptions (Ries, 2011).

Maurya (2012) states that it could potentially lead to waste and is very time consuming when building the right solution for the wrong problem or when possessing an excess of unwanted attributes. His solution is building 'just enough' of the answer to customer problems for the purpose of gaining their feedback. He furthermore points out that the MVP should be "realizable, look real, quick to iterate, and minimize waste" (Maurya, 2012, pp. 127-128). He builds upon the earlier statements of Blank (2006) and Ries (2011) with this approach. Bosch et al. focus on the validation of the MVP and concern themselves with the question of what features are needed for the MVP (Bosch, Holmström Olsson, Björk, & Ljungblad, 2013). This leaves the assumption that the MVP has a critical role in the software start-up development model.

Finally, Moogk (2012, p. 25) states that "start-ups can benefit from the lean start-up methodology, especially from the ideas and learning generated as a result of testing an MVP against the relevant metrics." Furthermore, she highlights potential first-mover benefits by shorter time to market (Moogk, 2012).

5.2 Build-Measure-Learn feedback loop

Another facet that was mentioned multiple times in literature is the Build-Measure-Learn feedback loop (BML loop). This cycle can be regarded as a classical scientific hypothesis-metric-experiment cycle that starts with the learning goal and ends with an experiment testing the hypothesis.



Build-Measure-Learn feedback loop. Source: (Maurya, 2012)

Furthermore they advocate that the BML loop can be utilized for entire processes as well as smaller decisions in contrast to traditional design-thinking, which cannot be used on a micro-level (Mueller & Thoring, 2012).

Ries (2011) states that before entering the loop, two important assumptions must be made, the value hypothesis and the growth hypothesis allowing for the engine of growth (which will be elaborated on in section 5.5) to be controlled. After those assumptions are made the first step is to enter the Build phase with an MVP, secondly the Measure phase can be started in which an assessment will be made if the development efforts lead to significant development. In the final stage, 'Learn', the most important decision has to be made: if the entrepreneur should reject or maintain the current strategy, a process called pivot which will be elaborated on in next section (Ries, The Lean Startup, 2011). Maurya (2012) describes the BML loop as the customer feedback loop that is developed to verify or disprove hypotheses. Bosch et al. (2013, p. 5) add that the BML feedback loop is "another central concept" of validated learning, with a focus on developing customer value while diminishing the risk of being too focused on the mere solution (Bosch, Holmström Olsson, Björk, & Ljungblad, 2013).

5.3 Pivot

The Pivot is a central concept used when start-ups alter their strategy based on the learning stage of the BML feedback loop. Pivoting is a significant strategic decision implying it is important for the lean start-up (Bosch, Holmström Olsson, Björk, & Ljungblad, 2013). Ries (2011) adds that a pivot is a controlled change plan preferably utilized for proofing new hypotheses about products, strategy and engines of growth, eventually putting the start-up on a path towards developing a sustainable business. He continues with claiming that pivoting is one of the most common occurrences within successful start-ups as they rarely end up doing what they originally aimed to do. Furthermore, faster decision making supports more iterations of the BML feedback loop and possibly more validated learning since more cycles can be completed (Ries, 2011). Mueller and Thoring (2012) furthermore state that pivoting is central to a concept called quickly failing, meaning that the earlier a hypothesis is proven wrong, the sooner adjustments to that hypothesis can be made in order to retest it. Also, it can be applied very early on in the process of the lean startup methodology. Blank (2013) creates support by stating that pivoting is storming the start-up world and that the approach is already being implemented by various business schools. He makes a clear distinction between small adjustments and the larger pivots which involve the formulation of new hypotheses (Blank, Why the Lean Start-Up Changes Everything, 2013). Furthermore, due to the assumption that failure is expected, the pivot seems to have become a central concept to start-ups. Maurya (2012) supports the approach that pivoting is about learning to validate the hypotheses and to discover a feasible proposal, also calling it a course of correction, building upon Ries.

5.4 Validated learning

As mentioned before, start-ups do not exist to merely develop a product or service but to learn to grow a sustainable business (Ries, 2011). This can be achieved by a process of validated learning, which is not as much a tool as it is a philosophy of the lean start-up methodology. Validated learning basically answers the question 'was it any good?' and can be subdivided into qualitative and quantitative validation. Qualitative validation is used for unveiling any pro's or cons in the hypothesis, while quantitative validation is no longer used for learning, but for attaining significance of the outcomes (Maurya, 2012). To achieve validated learning, the build-measure-learn feedback loop can be utilized.

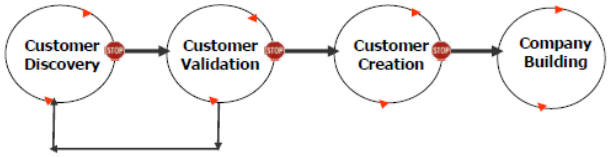
Bosch et al. (2013) mention validated learning as a concept of the BML loop, implying that it is a significant part of the lean start-up methodology. Furthermore, they argue against obvious success factors existing in lean startups, however, the companies Bosch studied did not use the process of validated learning (Bosch, Holmström Olsson, Björk, & Ljungblad, 2013).

5.5 Engine of Growth

The engine of growth is not mentioned as often as other facets of the lean start-up methodology, however it is still significant. Amongst others, Ries (2011), as founder of the lean startup methodology, advocates that the engine of growth is a vital facet towards building a sustainable business. Furthermore Maurya (2012), and Bosch et al (2013) build upon his findings also deeming it a significant facet. According to Ries (2011) the engine of growth is the mechanism that start-ups use to achieve sustainable growth. It can be subdivided into three engines, (1) "the sticky engine of growth, focusing on customer retention, (2) the viral engine of growth, relying on the *viral coefficient* measuring the amount of new customers that will use a product as a consequence of every new customer that has signed up, and (3) the paid engine of growth, assuming a company can grow in two ways, increasing revenue per customer or driving down the costs of attaining a new one" (Ries, 2011, pp. 209-219). Similar descriptions can be found in (Moogk, 2012). Building upon these three engines, Maurya (2012, pp. 212-213) provides a few guidelines that can be used to help select the entrepreneur which engine he needs; starting with "validating the value metrics (1), understanding how customer behave with the product (2), and pick an engine to tune (3)".

5.6 Customer Development

Customer development is the pursuit of a startup towards a viable business model (Blank, 2013). Blank argues that customer development is a paradox: "It is followed by successful start-ups, yet articulated by no one" (Blank, 2006, p. iv). It starts with the simple principle that learning and discovering what customers to attract and what markets they are in, requires a separate process from product development. The customer Development model was developed in this light and exists of four stages.



I. Customer discovery: discovering who your customers are and whether the problem the entrepreneur and his start-up solve is important for those customers;
II. Customer validation: essential stage in understanding whether the product pushed to market is wanted by a customer base together with a blueprint on how to market it;
III. Customer creation: the goal here is to create end-user demand, while moving to more heavy marketing spending after the initial customers are obtained;
IV. Company building: In the final stage the adjustment from learning and informal teams is made towards focusing on mission-oriented departments to exploit early market success.

Customer development model. Source: (Blank, 2006)

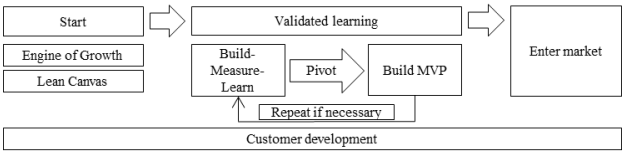
Other studies mention customer development as well. Blank (2013, p. 69), calls his own approach a "get-out-of-the-office" approach, arguing it to be a superior alternative to designing anything upfront. He also states that it identifies on a modest scale with agile development by not having the burden of year-long development cycles (Blank, 2013). Mueller and Thoring (2012) state that the customer development model is actually a fundament of the lean start-up methodology which makes it an important aspect according to them. Furthermore, Ries (2011) claimed that the customer development philosophy guided him in his work as an entrepreneur towards the lean start-up methodology. Finally, (Maurya, 2012) and (Bosch, Holmström Olsson, Björk, & Ljungblad, 2013) also pay attention to customer development.

5.7 Lean Canvas

Although not extensively mentioned, the lean canvas is a helpful tool in the early phase of the lean start-up methodology. A lean canvas is a one page version of the business model canvas which is "fast, concise, and portable" (Maurya, 2012, pp. 24-25). Advantages exist in the fact that a lean canvas only takes several hours to construct in contrast to multiple weeks or months. Furthermore, the canvas pressures the entrepreneur to focus only on the critical aspects of the business model in order to give his start-up clear direction. Finally due to the limitation to one page, there is a lower threshold to read the canvas (Maurya, 2012).

5.8. Chapter summary

The studies identified in the systematic literature review do not provide a model linking all facets together. Therefore, this thesis presents a new model, based on the extensive and exhaustive literature review.



An overview of the typical facets of the lean startup methodolgy

Having provided an analysis of the significant facets the lean start-up methodology embodies, and a model to improve the understanding of the reader, the next section will regard the typical processes of new product development in established firms.

6. NEW PRODUCT DEVELOPMENT IN ESTABLISHED FIRMS

In the following section multiple methodologies of new product development, identified by analyzing literature, will be highlighted.

"New product development practices (NPD) have been well studied for decades in large, established companies" (Marion, Friar, & Simpson, 2012, p. 639). In their paper Dixit and Aggrwal (2015) state that conventional firms decide prior to customer feedback on all issues regarding design, affecting quality and

commercial potential. It was only a few decades later that customer need analysis was introduced as a factor for product success. Furthermore they provide us with the traditional methodology of new product development, developing seven stages necessary for the production of a customer-design.

- Customer need analysis
- Defining the design data
- Selection of the processes and sequences
- Making of prototype
- Testing and evaluation
- Documentation
- Handover to production
  Source: (Dixit & Aggrwal, 2015)

Secondly, another specification by Crawford and Benedetto (2011) of the product development process is "Opportunity identification and selection, concept generation, concept or

project evaluation, development, and launch" (Dixit & Aggrwal, 2015, p. 88), largely corresponding to the former methodology, but containing six stages. A third definition of the product development process comes from (Ward & Sobek II, 2014) identifying 'Design system, design sub-system, test sub-system, test system, and launch' as key elements of the product development process. Consequently, a table with differences between the conventional NPD process and the Lean Product Development process is provided by Dixit & Aggrwal (2015), unveiling the significant difference in approach.

Characteristics	**Conventional New Product Development**	**Lean Product Development**
Design attributes and decisions.	Made by designer or development team on knowledge base	Made by customer need analysis and delayed or neglected if not necessary
Selection of the processes and decisions	Sequence was defined as the product to be manufactured. Bottle neck and idle man/machine time was biggest issue	Removes all types of waste from the process Bottle neck and idle man/machine time. Better utilization of resources.
Prototyping and testing	Verification to determine what needs to be fixed. Aim of testing was to find the problem in the product	Build knowledge to make decisions and achieve optimal designs. Aim of testing is now to check design characteristics
Manufacturing Involvement	Manufacturing is follower and advisor – receives design	Customer drives and sets tolerances and key characteristics

Differences in NPD and lean product development. Source: (Dixit & Aggrwal, 2015)

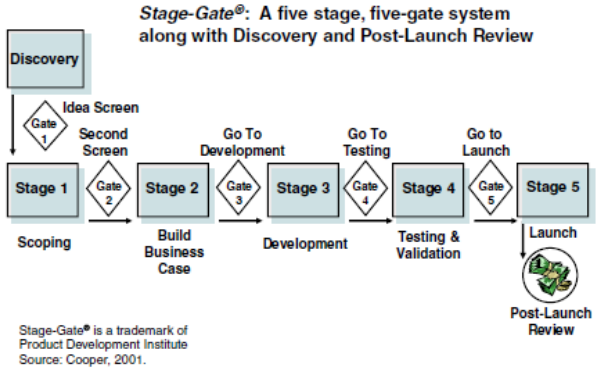
In order to assess the important facets of the new product development process, the scientific studies identified in the second shift of the SLR have been analyzed. The literature brought forth four significant facets of the NPD process, shown below.

	Stage-Gate	Maximizing customer fit	Flexibility	SD/mock-ups
Cooper (2008)	X	X	X	X
Schilling & Hill (1998)		X		
Hoyer (2010)		X		
Oorschot et al (2010)	X	X	X	
Loch (2000)	X		X	
Davidson et al (1999)			X	

6.1 Stage-Gate

A traditional approach in managing new product development processes is the Stage-Gate model, a process utilized by large firms. Well-established companies like Procter & Gamble, Emerson Electric, ITT and 3M have already used and benefited significantly from this approach (Cooper R. , 2008). The Stage-Gate model describes a process for pushing ideas to market, "a blueprint for managing the new product development process to improve effectiveness and efficiency" (Cooper R. , 2008, p. 214). A typical Stage-Gate process contains a set of stages each followed by a gate, the amount of stages can be adjusted depending on the importance and length of the project. At the gates a decision is made whether to 'go' or 'kill' the project resulting in either a continuance or disruption of funding. A figure containing the stages is shown below.

The stages all have the goal to minimize risk and uncertainty and require incremental commitment, meaning that whenever a new stage is entered the costs rise gradually. Furthermore the goals within a stage are done in a parallel manner and all stages are cross functional, implying that during the process no particular stages consisting of merely marketing or R&D activities exist. (Cooper R. , 2008). Furthermore it is argued that the Stage-Gate process is the cornerstone of NPD processes in firms. (Loch, 2000). Other literature also suggests that Stage-Gate is an organic system, repeating or discerning some stages when a high level of uncertainty or complexity is present (Oorschot, Sengupta, Akkermans, & van Wassenhove, 2010).



Stage-Gate process. Source: (Cooper R. , 2008)

6.2. Maximizing customer fit

Schilling & Hill (1998) argue that if firms want to succeed at new product development customer needs should be taken into account and a fit should be achieved. Hoyer et al. (2010) discuss the impact of co-creation of products in collaboration with the customer base amongst different stages in new product development. Advantages are amongst others the minimization of costs and substituting the cost of an employee with the free input of a customer. It is also stated in the same paper that through optimized customer fit of products, gained by co-creating products with customers, products have potential higher market value. On the other hand, however, when utilizing co-creation, the control over the innovation process decreases and can have negative consequences for firm performance. Besides that the complexity of keeping all shareholders satisfied increases (Hoyer, Chandy, Dorotic, Krafft, & Singh, 2010). Furthermore, Cooper (2008) describes processes in new product development that foster the input of external sources through open innovation, leading to a better fit.

6.3. Spiral development (SD) loop & mock-ups

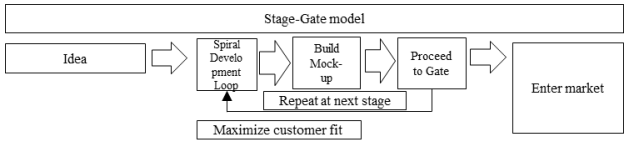
Cooper (2008) discusses the adaptability of the Stage-Gate process using a term called spiral development. "Spiral development bridges the gap between the need for sharp, early, and fact-based product definition before development begins versus the need to be flexible.... It is a process of Build-Test-Feedback-Revise loops" (Cooper R. , 2008, pp. 224-225). An advantage resulting from this spiral development approach is that customer feedback regarding the product can be integrated even when the product design has already been defined, next to the fact that after each spiral development loop feedback is already provided. Another focus point of spiral development is the early-involvement of customers in the process by investigating customer desires for future problems after which mock-ups (prototypes which only contain part of the full functionality of a product) are developed incrementally to eventually meet the desires and come up with a complete product, while minimizing waste. (Cooper R. , 2008).

6.4. Flexibility

Companies are dependent on flexibility when it comes to new product development (Loch, 2000) and (Davidson, Clamen, & Karol, 1999). Hoyer et al. (2010) also realize the potential co-creation has for organizational performance and if managed properly, two significant sources of competitive advantage can be gained: increased efficiency and increased effectiveness through better fit with customer needs which could lead to faster decision making and more flexibility. Furthermore Takeuchi and Nonaka (1986) state that speed and flexibility are of vital importance in the world of new product development.

6.5. Chapter summary

The literature analyzed did not provide a model for synthesis. Therefore a conceptual framework is now presented in order to provide a clear overview of how these facets interact. It should be noted that the process of proceeding from a spiral development loop towards the creation of a mock-up exists normally once per stage of the Stage-Gate model.



An overview of the typical facets of new product development

7. FINDINGS

In the previous sections first (section five) typical facets of the lean startup methodology were outlined after which (section six) a similar approach was conducted for the new product development process. Some dissimilarities between conventional new product development and lean product development came to light based on - amongst others - the premises of Dixit &Aggrwal (2015). On the other hand, the Stage-Gate approach complemented with the spiral development loops shows some promising parallels with the lean startup methodology suggesting that the lean methodology could be implemented in new product development processes in established firms. A table of the previously mentioned typical lean startup methodology and new product development facets is shown to provide a clear overview of the parallels between both methodologies.

Typical facets of LSM	**Typical facets of NPD**
Minimum Viable Product	Mock-ups
Build-Measure-Learn loop	Spiral development loop
Pivot	The adjustment of the NPD process whenever a high level of uncertainty or complexity is present
Validated learning	No parallel found
Engine of Growth	No parallel found
Customer Development	Maximizing customer fit
Lean Canvas	No parallel found

Typical facets in LSM and NPD

All facets of the LSM which have a parallel in traditional NPD will be compared in a brief description in the following section.

7.1 Minimum viable product vs. Mock-ups

The minimum viable product of the LSM and the mock-up of the NPD are similar. Both aim to incrementally develop a product based on customer feedback while minimizing waste. However, the minimum viable product prescribes to produce only the critical features when developing a product where the mock-up does not address that fact other than minimizing waste. Therefore the MVP seems more oriented towards customer needs and speed (and speed?) , while mock-ups adopt a more traditional approach.

7.2 Build-Measure-Learn vs. Spiral Development

The build-measure-learn loop and spiral development both consider building a product, gaining feedback and redeveloping. However, where spiral development is rather solution-oriented regarding product, the build-measure-learn loop aims at learning and testing hypotheses in order to improve customer understanding. Thus, the build-measure-learn loop has another, more long-term purpose than the spiral development loop. Furthermore, spiral development is a part of the Stage-Gate model but not as significant as the build-measure-learn loop in the LSM. The lean startup methodology proves successful while emphasizing this loop, offering a potential route to improvement

for new product development by incorporating a loop similar to the build-measure-learn, rather than the spiral development loop.
Pivot vs. Adjustment of NPD process

Both pivoting and the adjustment of the NPD process when uncertainty is high regard the decision to alter or keep the current strategy. In the LSM the decision whether to 'pivot or persevere' comes up periodically at the end of each build-measure-learn loop forcing the entrepreneur to actively reflect whether to follow or abandon the strategy. In the NPD process the choice only becomes relevant when a complex situation appears. In this light it seems that the LSM has a more proactive risk reducing character, considering the strategy to improve firm performance every iterative cycle in contrast to the NPD decision when uncertainty might be already too high or the adjustment of strategy too late.

7.3. Customer development vs. maximizing customer fit

'Maximizing customer fit' is also a very important facet of new product development, however a tangible plan of action how to achieve this fit is not properly addressed. The 'customer development' facet from LSM can offer a solution providing a solid four-step process on how to achieve customer fit. Furthermore the lean startup methodology considers the customer development facet during the entire process which ensures optimal customer focus, where 'maximizing customer fit' regards it too narrow, emphasizing 'customer fit' solely at two stages of the process.

8. CONCLUSION AND DISCUSSION

This research started with highlighting the important facets of the lean start-up methodology, , thereby providing insight in what they entailed. Thereafter the typical aspects of new product development were paid attention to. Comparing the Lean startup methodology with the Stage-Gate model led to the identification of four parallel facets: the minimum viable product, build-measure-learn feedback loop, pivot, and customer development. Although each of these facets correspond with a particular facet of the NPD process, the LSM facets seem more elaborate on different aspects such as customer fit, strategy adjustment, or customer understanding. Applying these LSM facets could thus improve NPD performance of established firms.

After conducting a systematic literature review the conclusion can be drawn that there are indeed facets of the lean startup methodology that can be implemented in new product development processes.

On the other hand, significant differences exist between startups and established firms, established firms are arguably not as flexible as starting firms. This is a very important aspect to keep in mind when considering implementing the lean startup methodology. Secondly, gaining customer feedback can be a difficult process for both startups and large firms, both facing different challenges. Where established firms possess a large amount of data because of the large customer base, startups have a favorable character given the popular character of crowdfunding platforms but no existing customer base.

The confidence that these facets could also be implemented in practice and not just in theory finds support in different studies providing examples that larger firms are already successfully implementing lean principles to the process of product development. (Blank, 2013), (Dixit & Aggrwal, 2015), (Kreafle, 2011) and process development (Khan, et al., 2011).

Limitations of this research lie in the fact that since this is a bachelor thesis the amount of time was limited. With more time a more extensive literature review could have been carried out.

A suggestion for further research is a case study, applying the identified facets of the lean methodology in practice at established firms. Repeating studies with a different research method – case study versus literature research – and finding the same results improves the validity of those results significantly.

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10. APPENDIX

Top 25 journals: technology and innovation management

Rank	Journal	Times cited (2006-2010)	Scopus coverage?
1	Research Policy	837	Yes
2	Strategic Management Journal	454	Yes
3	Journal of Product Innovation Management	425	Yes
4	Management Science	300	Yes
5	Academy of Management Journal	295	Yes
6	Harvard Business Review	264	Yes
7	Academy of Management Review	209	Yes
8	Research-Technology Management	205	Yes
9	Organization Science	184	Yes
10	Technovation	162	Yes
11	R&D Management	128	No
12	Industrial and Corporate Change	112	Yes
13	Journal of Marketing	110	Yes
14	American Economic Review	108	Yes
15	IEEE Transactions on Engineering Management	98	Yes
16	Journal of Business Venturing	94	Yes
17	Journal of Technology Transfer	91	Yes
18	Technological Forecasting and Social Change	83	Yes
19	MIT Sloan Management Review	83	Yes
20	Journal of Engineering and Technology Management	71	Yes
21	Journal of Marketing Research	66	Yes
22	International Journal of Technology Management	62	No
23	Administrative Science Quarterly	60	Yes
24	California Management Review	59	Yes
25	Science and Public Policy	58	Yes

Coverage top 10	Coverage top 25
100% *(10/10)*100*	***92%*** *(23/25)*100*