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Lean-startup's impact on New Product Development

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Abstract

The current globalized environment puts companies in a cross path to either innovate or perish with time and high-intensity competition. This makes new product development and its best practices key stakes for any company wanting to construct a sustainable innovation advantage; to that end, many companies and ecosystem builders adopted and still are adopting the Lean-startup framework, which has gained popularity since its appearance in 2010.Even though it is widely popular, the literature on its exact impact is still insufficient, contrary to similar frameworks. In this dissertation, we try to discover what impact does Lean-startup has on new product development and, more precisely, from a financial performance and innovativeness perspective as well as taking into account circumstantial factors that could influence the adoption. This is done by developing a corrected scale for measuring Lean-startup adoption, followed by a quantitative methodology with product managers. Surprisingly the analysis showed no significant correlation between new product innovativeness and financial performance and Lean-startup adoption as a whole. However, a significant link was found with one of its components. The findings have implications for future Lean-startup research, product managers, and companies.

Key words: Lean-startup – New product development – Innovation – Agile framework.

ملخص

تضع بيئة العولمة الحالية الشركات في مقتطع طرق إما الابتكار أو الاندثار مع الوقت والمنافسة الشديدة. هذا يجعل تطوير المنتجات الجديدة والحرص على القيام بأفضل ممارساتها رهانات رئيسية لأي شركة ترغب في بناء ميزة ابتكار مستدامة؛ لتحقيق لهذه الغاية، اعتمدت العديد من الشركات وبنائي النظم البيئية ولا يزالون يعتمدون إطار العمل المعروف باسم" الستارت اب الرشيق". اكتسبت هذه المنهجية شعبية منذ ظهورها في عام 2010 لكن على الرغم من ذلك، الأبحاث حول تأثيرها على تطوير المنتجات الجديدة لا تزال غير وافية، على عكس أطر العمل المماثلة. في هذه الرسالة، نحاول اكتشاف تأثير "الستارتب الرشيق" على تطوير المنتجات الجديدة، وبشكل أكثر دقة، من منظوري الأداء المالي والابتكار، فضلاً

عن مراعاة العوامل الظرفية التي يمكن أن تؤثر على تبني هذا الإطار. يتم ذلك من خلال تطوير مقياس مصحح لقياس اعتماد "الستارتب الرشيق"، متبوعًا بمنهجية بحث كمية مع مديري المنتجات. من المثير للدهشة أن التحليل أظهر عدم وجود علاقة قوية بين ابتكار المنتجات الجديدة والأداء المالي وتبني "الستارت اب الرشيق" ككل لكن تم مع ذلك، العثور على ارتباط كبير بين الأداء المالي وأحد مكونات إطار العمل. النتائج لها آثار على أبحاث مستقبلية وتهم كذلك لشركات ومديري المنتجات.

الكلمات المفتاحية: الستارت اب الرشيق – تطوير المنتج الجديد – الابداع – إطار العمل المرن.

Résumé

L'environnement mondialisé actuel met les entreprises à la croisée des chemins pour innover ou périr avec le temps et face à une concurrence intense. Cela fait du développement de nouveaux produits et de leurs meilleures pratiques des enjeux clés pour toute entreprise souhaitant se construire un avantage durable en matière d'innovation ; à cette fin, de nombreuses entreprises et constructeurs d'écosystèmes ont adopté et continuent d'adopter le cadre Lean-startup, qui a gagné en popularité depuis son apparition en 2010. Bien qu'il soit largement populaire, la littérature sur son impact exact est encore insuffisante, contrairement à d'autres cadres similaires. Dans ce travail de recherche, nous essayons de découvrir quel est l'impact du Lean-startup sur le développement de nouveaux produits et, plus précisément, d'un point de vue de la performance financière et de l'innovation ainsi que de la prise en compte des facteurs circonstanciels qui pourraient influencer l'adoption. Pour ce faire, nous développons une échelle corrigée pour mesurer l'adoption du Lean-startup, suivie d'une méthodologie quantitative avec les responsables de produits. Étonnamment, les résultats de la recherche démontrent qu'il n'y a aucune corrélation significative entre la capacité d'innovation et la performance financière des nouveaux produits et l'adoption du Lean startup dans son ensemble. Cependant, un lien significatif a été trouvé avec l'une de ses composantes. Les résultats ont des implications pour la recherche future sur le Lean-startup, les gestionnaires de produits et les entreprises.

Mots-clés: Lean-startup – développement de nouveaux produits – Innovation - Cadre Agile

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Introduction

With the global startup economy reaching a size of 3 trillion dollars at the end of 2018, innovation is an ever-increasing stake, with countries racing to develop and enrich their ecosystems and companies investing large amounts more than ever in R&D (*The $3 Trillion Global Start-up Economy Where and How Start-up Ecosystems Are Driving New Growth*, 2019). Under these circumstances, the process with which to bring new products into life or new product development and its design become critical, aspects like best practices and an obsession with customer adoption are being put at the forefront of companies' goals, in the words of Jeff Bezos about Amazon's vision "Our goal is to be earth's **most customer-centric** company."

Most companies now are quite familiar with Agile methods, as they provide efficient and effective delivery of products. However, since its creation, Agile was mostly used in software products, so when Lean-startup came about in 2010, it disrupted the body of knowledge of startups and innovation by adopting Agile principles to the general product development process relieving the software restriction.

These insights push us to pose the research question, "what indeed is the Lean-startup framework's impact on new product development" to answer this question, sub-questions are asked and used to form hypotheses.

- What is the impact of Lean-startup adoption on new product performance?
- What is the impact of Lean-startup on new product innovativeness?
- Is there a relationship between a company's innovation culture and Lean-startup adoption?
- Is there a relationship between competitive intensity and Lean-startup adoption? i.e., Do companies tend to adopt Lean-startup to gain a competitive advantage if not for direct New product development benefit?
- Is the impact of product management experience on new product performance significant and thus more worthy of attention?

In the present work, we aim to discover general tendencies related to Lean-startup and new product development by a quantitative study over many industries. The chosen sample is purely product management practitioners as respondents.

Contrary to previous works on Lean-startup, factors such as company innovation culture and competitive intensity were considered and operationalized.

Due to the Covid-19 related circumstances, the research's methodology and terrain were changed, and the research was conducted while doing an internship at the company ***Yassir***

SPA; as a startup that practices continuous innovation, the company is very relevant to the chosen theme.

The dissertation starts with a literature review that contains a general introduction to New product development. It proceeds to mention general trends and aspects in the domain before going into Lean-startup origin, core concepts, and similar and preceding frameworks before going into practice as dictated by the mentioned methodology.

The work reinforces previous research and provides a corrected scale for Lean-startup adoption measurement to be used in future research as well as several insights that interest product management professionals, companies, and organizations interested in innovation.

Chapter 1: Theoretical framework

1. Literature review

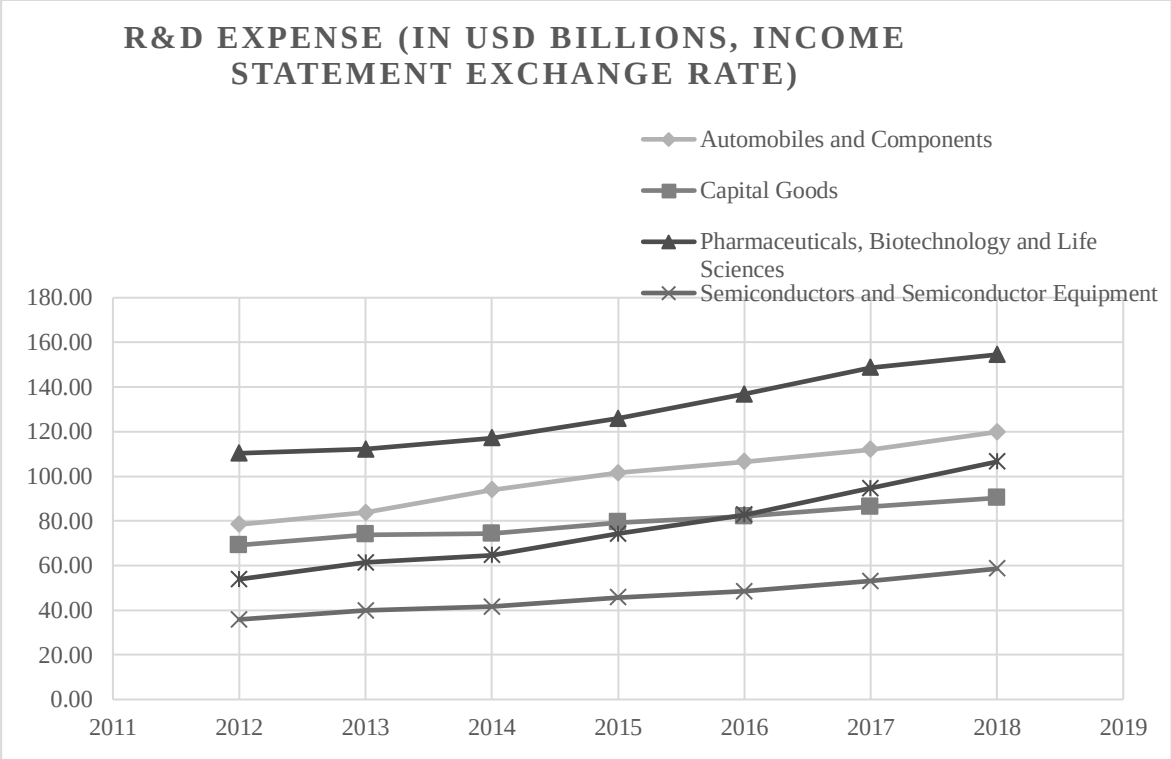
In this subchapter, a review was done on previous research related to Lean-startup in particular in addition to providing a general view on new product development with an inclusion of the customer orientation aspect.

1.1. The field of New product development and its original models:

Research on new product development (NPD) has been thoroughly developed in the last decades; one of its leading journals, the journal of product innovation management, saw its yearly citations jump from 40 to 400 in 11 years (Page & Schirr, 2008). With areas such as customer orientation and customer inclusion in the development process well developed.

Regarding the innovation sector as a whole, we can observe the following graph that was made from the data collected by PricewaterhouseCoopers (2018), from the largest 1000 publicly listed R&D spender. The graph shows the five industries observed to be spending the most on R&D.

Figure 1 Growth of R&D expenses top consuming industries



Adapted from PricewaterhouseCoopers (2018)

As we can see, the global trend is increased spending on R&D, with the pharmaceutical and the automobile industries leading the way. Global spending on R&D finished up with a record-high of $782 billion in 2018 (Goehle, 2018).

These figures emphasize the stakes in question when talking about the processes that bring about new products to market and provide a strong argument for the usefulness of using New Product Development best practices.

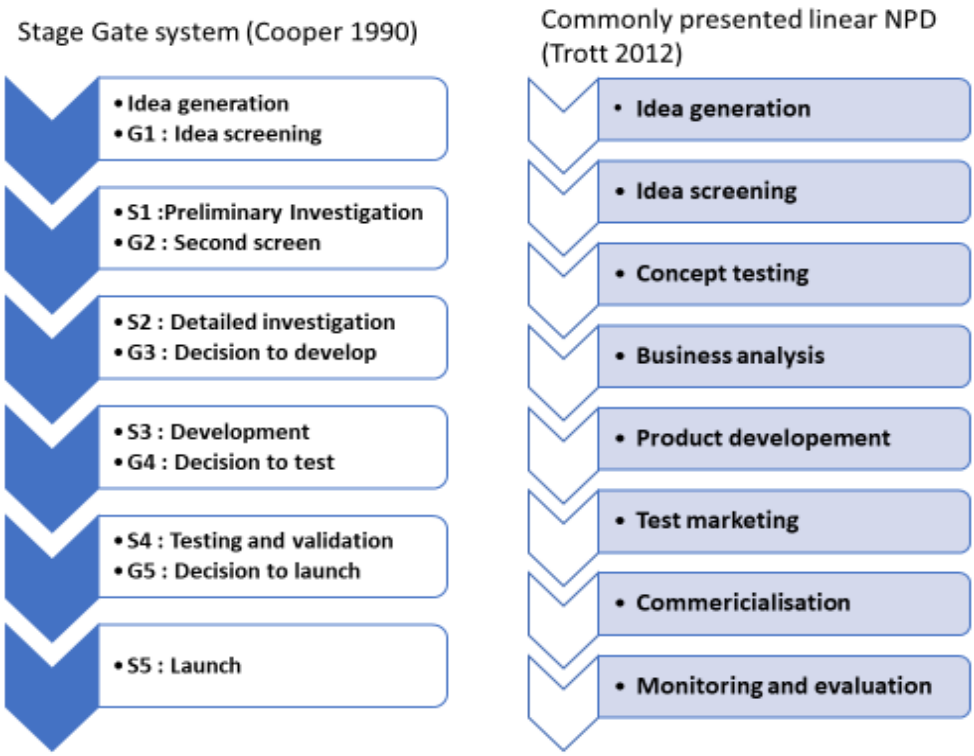
According to York & Danes (2014), the traditional NPD model seems to be under the influence of the stage-gate model. This linear model approaches product development by phases with predevelopment (feasibility), development, and test and then manufacturing activities.

The model was originated by (Cooper, 1990; Cooper et al., 2004); figure 2 below shows the traditionally presented NPD model and the original stage-gate model for comparison.

Both the linear and the stage-gate model are often criticized for being too rigid with the notion of going back to the previous gate or phase being indicative of a mistake (Cooper, 1990; York & Danes, 2014). Cooper adapts to some of the critics by introducing his updated model in 2014, a hybrid approach that is supposed to be Agile, Adaptive, and Accelerated.

The logic behind the stage-gate model is based on the assumption that further costs and risks can be avoided in the next stages by doing detailed planning early on in the project.

Figure 2 : Traditional Stage-Gate System Cooper (1990) and the commonly presented linear NPD model Trott (2012)



Made by ourselves via word

The argument being that as an idea advances through the stages, costs dedicated to it increase dramatically, with the most consuming part being the technical development. However, early reasoning did not foresee the decreased cost of prototyping that is a characteristic of this era, as prototyping through 3D printing is considered widely popular.

This new development and similar others, supports ongoing concerns on this linear model's current validity for innovative products, especially with the rapidly changing environment.

Cooper (1990) mentions that his model helps avoid the common mistakes called **GO / NO-GO** mistakes, with GO being the execution of a bad idea and the NO-GO being the elimination of a good idea.

He argues that the probability of these mistakes can be decreased dramatically using screening gates with executives. Still, until the testing phase is reached, customer interaction and therefore, feedback on the product is not a priority, unless at least a member of the jury "Gatekeepers[1]" is customer-oriented.

If we count on getting customer feedback only from the testing stage onwards, that leaves little space for significant changes in the new product (Salomo et al., 2003).

[1] Gatekeepers: senior executives in charge of approving the project going from one stage to another.

1.2. Best practices in New Product Development

Research on best practices in NPD is a primary orientation in the field. Kahn et al. (2012) mention among best practices: having NPD goals aligned with the firm's long-term strategy and mission, regarding the process: a standard unified NPD process as well as clear exit criteria for each gate, the availability of documentation, and the flexibility of the process to customer needs. In contrast, having limited to no process documentation, no clear NPD manager, no clear criteria for evaluation, and minimal testing are considered poor practices.

Regarding the research dimension, best practice firms have ongoing market research to anticipate future customer needs; they use testing consistently, whether it is the market, the product, or concept testing, with results being evaluated formally (Kahn et al., 2012).
The customer plays a central role in the process, contrary to firms with poor practices that do not involve the customer/user and conduct incomplete market research. This finding was supported in early studies by Cooper (1990), who found that successful new products have twice the budget for market research than failed ones.
An interesting point in the metrics dimension that Kahn et al. (2012) mentions: projects are never stopped or aborted in firms with poor practices. This notion exists in Lean-startup when the company cannot ***pivot*** [2]anymore.

1.3. Lean-startup

In opposition to the linear progression of activities, we find the approach studied Lean-startup by Ries (2011), who criticizes the previous model and calls the conventional way of product development.
Lean-startup principles view writing a detailed business plan based on assumptions before getting the product to the market as safe and sufficient for existing goods/services. Reason being that their market specifically and their business model, in general, is well determined. However, when it comes to innovations, the previous approach can lead to what Ries calls *"successfully executing a failed plan" Ries (2011),* as the optimism in assumptions leads the company to invest large amounts on risky endeavors. Investments such as scaling[3] infrastructure intending to support a large number of clients predicted by initial marketing

[2] Pivot: "structured course correction designed to test a new fundamental hypothesis about the product, strategy, and engine of growth." (Ries, 2011)

[3] Scaling: (short for scaling up) increasing the capacity at which the company can serve customers.

research (Blank, 2004; Ries, 2017), without confirming the product's ***"value hypothesis"***[4] (Ries, 2011) with actual customers.

Ries thus proposes his approach, which aims to test hypotheses while minimizing wastes and, through iterations, arrive at a ***product-market fit*** [5] stage in which it is safe to scale the business. During that journey, hypotheses are confirmed or rejected, and "pivots" or changes in the strategy are made.

The approach also mentions a tool for progress measurement called Innovation accounting, which focuses on input variables that drive customer behavior. The financial reports are not yet or not wholly indicative of performance at the start of the project. Innovation accounting is further articulated in Ries's second book, ***"the startup way."***

Ries draws his arguments from his experiences with the startup he confounded IMVU and from experiences with other startups or innovation endeavors he observed.

According to CB insights (The Top 20 Reasons Startups Fail, 2019), which analyzed 101 failed start-ups, the number one reason reported for failure at a percentage of 42% was "no market need," which helps Ries's claim for the failure due to the wrong assumption of value. Nevertheless, another reported reason at 19% was being outdone by the competition since competition intensity is a core characteristic of the current globalized business environment. A business plan is supposed to avoid that via competitive analysis.

Ries defines a startup as *"A human institution designed to deliver a new product or service under conditions of extreme uncertainty"*(Ries, 2011),

This somewhat general definition argues that the essential characteristic of a startup is the uncertainty it tries to build itself in, which provides insights into the methodology's philosophy. Patz (2013) found that Lean-startup is suited for situations with " high uncertainty and ambiguity," thanks to notions of iterations originating from Agile programming methods (Ghezzi & Cavallo, 2018). The somewhat self-evidency of the Lean-startup principles makes its adoption sometimes happen without conscious effort from the practitioners. Research by J.A. Casselman (2016), who studied the application of Lean-startup in established firms, found that these firms use elements of the methodology without

[4] Value hypothesis: Eric Ries defines a value hypothesis by what it does "tests whether a product or service really delivers value to customers once they are using it."

[5] Product Market fit: one definition by Marc Andreessen is "*Product/market fit means* being in a good *market* with a *product* that can satisfy that *market*."

full knowledge 79% of respondents using the build-measure-learn feedback cycle and 69% of them reporting scaling operations after a product-market-fit is achieved, one of the goals for the framework. Cited benefits were low costs, early feedback, and higher customer approval. Factors found to aid success are rapid iteration and early pivots in response to feedback.

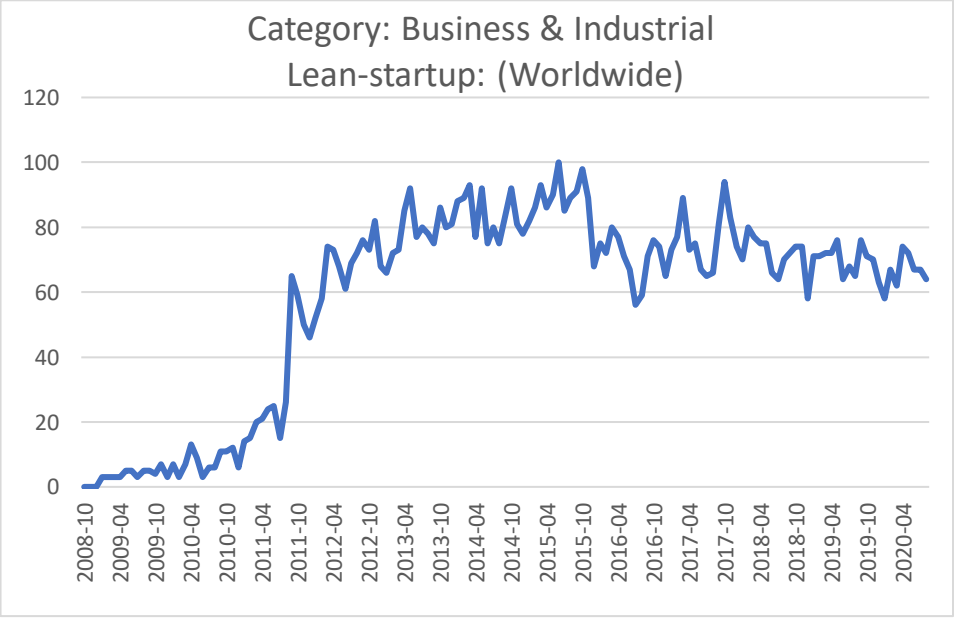
Among prior research, we also find those focused on implementation barriers, such as Nirwan & Dhewanto (2015). One of the main obstacles found in a business case study was scheduling customer interviews for feedback. The research also made recommendations for smooth implementation, such as early customer interaction necessity and market sizing when pivoting to avoid going after a customer segment that is not safe to build a business around, which is also recommended by Blank (2004).

Reported use of Lean-startup has been declared in companies such as general electric, Intuit, Etsy, Toyota, British telecom-O2 (J.A. Casselman, 2016).

The figure below shows the interest over time in Lean-startup demonstrated by the relative amounts of google searches performed containing the term.

It is to note that the term Lean-startup appeared in a blog post by the author in 2008 before the actual book was launched in 2011, which could explain the sudden jumps in both 2008 and in larger proportion 2011. It can also be noticed that Lean-startup continues to have relevance in searches of at least 60% of its peak during 2015.

Figure 3: Lean-startup google search trends in the business and industrial category



Adapted from Google Trends data (2020)

2. Conceptual framework

"New product development (NPD) consists of the firm's activities that lead to a stream of new or changed product market offerings over time. This includes the generation of opportunities, their selection and transformation into artifacts (manufactured products) and activities (services) offered to customers, and the institutionalization of improvements in the NPD activities themselves" (C Loch & Stylianos Kavadias, 2008, pp. 2–3).

In essence, new product development comprises the processes with which the firm brings about new products from idea to launch and how it can improve those processes. The field is relevant to the case of startups or internal innovation endeavors.

2.1. Key new product development concepts

Below are a set of key concepts chosen for being relevant to almost any discussion about new product development; they are also vital stakes to manage while assessing the implementation of experiments in developing new products.

2.1.1. Fuzzy front end (FFE)

Trott (2012) explains the fuzzy front end as the *"The messy getting started period of product development"* where the enterprise is exploring and developing the concept before investing resources. The word fuzzy comes then because the detailed description of the product is not finished, thus fuzzy.

The fuzzy front end includes, according to Kahn (2013) 3 main tasks: strategic planning, concept generation, and especially pre-technical evaluation, while for Trott (2012), it includes all activities from the start of ideation to the precise development of a concept, a similar idea is found in cooper's work under the name *predevelopment homework*.
Cooper & Kleinschmidt (1994) found a strong correlation between the quality of "upfront homework[6]" and timeliness or shorter cycle time[7] and vice versa, projects with poor quality

[6] Upfront homework: "the first few steps of the process: the predevelopment" (Cooper, 1990)

[7] Cycle time: "The speed with which an operation takes place from beginning to end. In product development, cycle time is often the time it takes from concept to product launch." (Haines, 2009, pp. 643–676)

predevelopment homework didn't perform so well, which is relevant since FFE activities can consume up to 50% of development time (Trott, 2012) while not particularly consuming large capital but heavily impacting cycle time and Time-To-Market.

While Cooper & Kleinschmidt (1994) try to maximize chances for success by doing pre-development activities, Cooper does point out the benefit of rapid prototyping, saying that firms who have done rapid prototypes and tests minimized "unpleasant surprises." That might suggest that the before mentioned homework can be done in several forms as long as to arrive at the same benefits and could be one of the reasons Blank (2004) suggests his model one of the bases for Lean-startup, the customer development model as a process to be taken in parallel to product development and not to replace it.

2.1.2. Time to market and general firm orientations

Another important factor when discussing new product development processes is Time-To-Market or TTM: *"The length of time it takes to develop a new product from an early initial idea to initial market sales."* (B. Kahn, 2015).

In industries manipulating technology and under rapid change, Time-To-Market is an essential metric for comparing performance with competition (Trauffler & Tschirky, 2006). However, its appropriate value depends on the company's strategy, that is because an overstress on minimizing Time-To-Market can lead the firm to overly staff the project, thus losing cost-wise (Trott, 2012).

Crow (2007) considered a focus on Time-To-Market a *"product development strategic orientation*" next to choices such as low product cost, product performance technology, and innovation, as explained in Table 1 below. In addition to being used in such a matter, Time-To-Market is used as a metric to measure innovation efficiency and the on-time performance by over 80% of firms (Cooper, 2008)

In the case of releasing multiple times in different versions, TTM can be used for the time taken by each iteration.

Table 1: Primary Product development orientations.

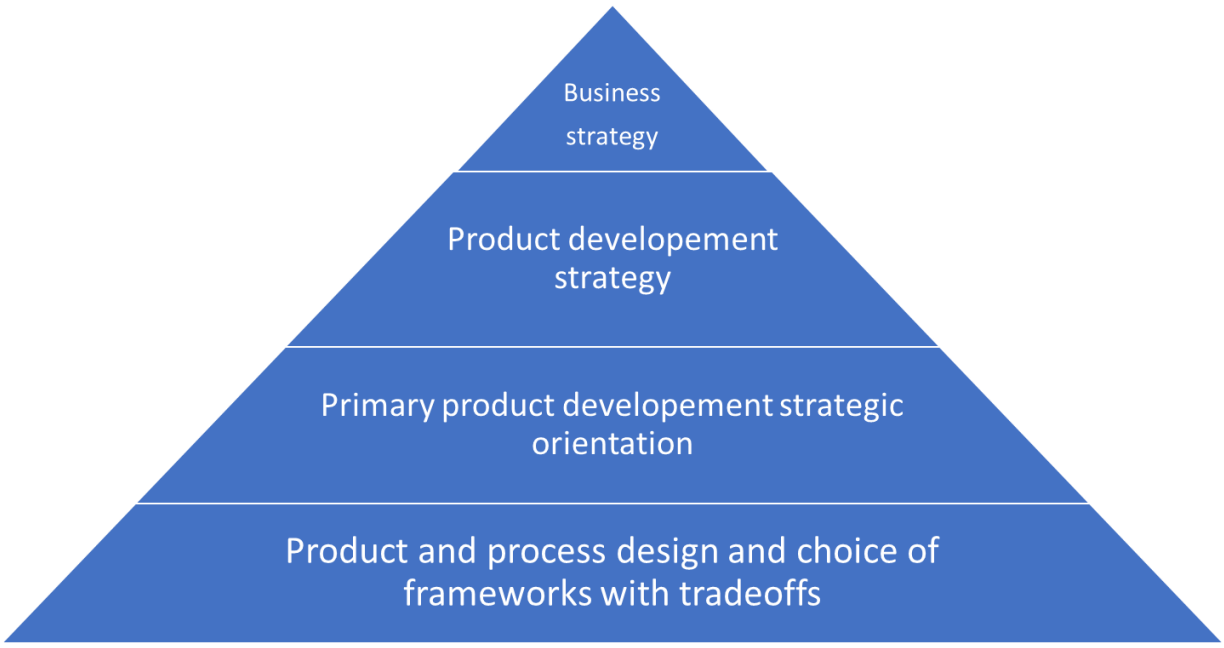
Primary product development orientation	Explanation
Time to market	Getting to market faster is a characteristic of rapidly changing industries. Crow recommends that technology evolution happen in a parallel path and added on a modular base to balance the tradeoffs of optimizing product performance and reliability.
Low Product Cost	For products reaching the mature phase or have a shrinking market, typical for commodity-type products consumes time to provide the highest value.
Low development cost	Common between companies under development contracts, or undertaking stealth development, can work with TTM while considering tradeoffs with performance reliability and innovation.
Product Performance, Technology and Innovation	A high-risk strategy aiming at achieving the highest levels of each mentioned criteria (performance, technology, innovation), it involves trade-offs with cost and time.
Quality, Reliability, Robustness	Typical in industries where high quality is needed due to safety or cost concerns involves tradeoffs regarding TTM.
Service, Responsiveness and Flexibility	Being responsive to customers while maintaining flexibility for new opportunities and markets needs additional resources.

Adapted from (Crow,2007)

2.1.3. Customer orientation and involvement

Typical roles that the customer plays in NPD include being an information resource, a co-creator, and a user (Nambisan, 2002). Which approach to adopt depends on the needs of the enterprise and the industry in which it lives; firms seeking a high degree of innovativeness require customer integration evolving around qualitative methods to have better performance (Salomo et al., 2003). Worth noting what Cui & Wu (2016) recommends is establishing clear customer roles and boundaries of collaboration. Using two forms of customer involvement (customer as an information resource and as a co-creator[8]) can generate conflicting information. Multiple forms of customer involvement might be needed while one, in particular, might be preferred, for example, the customer as co-creator when the experimentation rate is limited (Salomo et al., 2003).

Figure 4: Business strategy to product development process



Made by ourselves amended from Crow (2007) and revised by the original author (PPT)

To summarize, before going to Lean-startup, as in the figure above, the process design of product development and, in turn, the choice between frameworks is strongly linked to the needs of the enterprise as dictated by its business strategy (Crow, 2007), it sets the stage for

[8] Co-creator: "As co-creators of products, customers can contribute to a variety of product design development.

choosing its strategic orientation as a first step in determining its product development strategy.

2.2. Lean-startup and other Product development models

In order to distinguish Lean-startup differences from other models, a short description of some of the most used models and those that are similar and/or are considered precursors for the Lean-startup are made bellow.

2.2.1. Lean-startup origin and concepts

Ries says in his first book "*The Lean-startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" (Ries,2011)* mentions that his model is a composite model that draws a lot of concepts and tools from previous models such as lean management, customer development, and design thinking. It also offers concepts of its own such as the Minimum Viable product, innovation accounting, hypothesis stating, and others. These and others are explained below.

Lean management

Lean management originates from the book *"The machine that changed the world "(Womack et al., 1990),* a book that sparked a philosophy which a very large number of organizations adopt as well as having a large continuous pool of research, over 20000 research papers associated with lean have been published (Gupta & Jain, 2013).
In their second book, "*Lean Thinking,"* Womack and jones describe lean as doing more with minimum human effort, equipment, time, and space, all the while heading towards customer exact want (Womack & Jones, 2003). To that end, they specify five steps of implementation:

1. Defining customer Value
2. Defining the Value Stream Flow,
3. Establishing a flow-based around customer pull
4. Striving for continuous improvement.

Lean-startup also uses the concepts of *Kanban*[9] for the actual development and *Small batches* aiming at having more transparency on production and minimizing defects in addition to *Just In Time*[10] JIT for scaling operations. The latter concept also a revision of a concept mentioned in the customer development model (Blank, 2004) that, among other goals, aims to avoid the previously mentioned *premature scaling.*

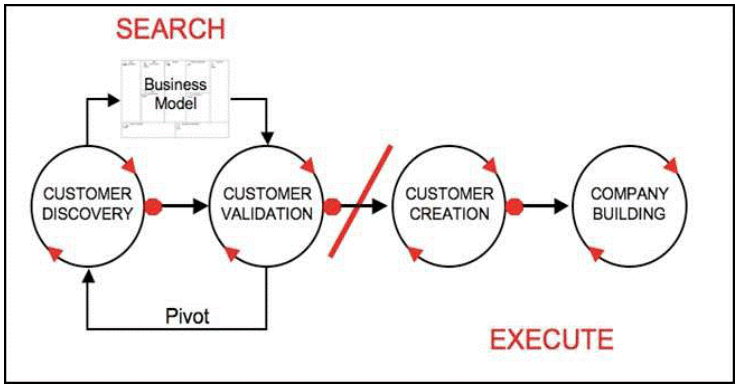
Customer development model

Lean-startup draws a lot of its concepts from the book "*Four steps to epiphany"* (Blank, 2004). In a Harvard Business Review article, Blank mentions that Lean-startup uses the customer development model after having come up with an idea using Design thinking and before going into feature product development using Agile development (Blank, 2013).

The model comprises of 4 steps with multiple tools used

1. Customer discovery: where the objective is confirming the existence of the customer and the importance of the problem to that relevant segment.
2. Customer validation: the exit criteria for this stage is that a set of customers care enough for the proposed solution enough to actually buy it.
3. Company creation: creating demand and driving it to the sales channel (Blank, 2004)
4. Company building: the transition to formal functions after the business model has been confirmed (sales, marketing, finance…).

Figure 5: Customer Development model



(Blank and Dorf, 2012)

[9] Kanban: "Used in Lean Software Development and adapted from Lean Manufacturing, Kanban is a signaling system, historically based around cards, to indicate demand for an item. Kanban is used to reduce inventory queues and work in progress (WIP). In manufacturing, the cards represent requests for parts needed for the next batch of work. In software the card represents a unit of work, such as a feature." (Cohen, 2010)

[10] Just-in-time: "(JIT) production means producing the right item at the right time in the right quantity." (Dennis, 2017, p. 116,)

MVP Minimum Viable Product and Build measure Learn

Defined by Ries as the version of the product that allows for the collection of maximum amounts of learning with the least effort, the MVP provides a tool that helps verify the company's assumptions early on and without over progressing into uncertainty, which can be too expensive to fix. This is done through but not restricted to high-resolution (sometimes called High fidelity ex: Digital mock-ups) and low-resolution (low fidelity ex: Paper prototypes) prototypes as in design thinking, doing the automatic work manually without client knowledge, which is called Concierge MVP, etc.

The model is based around experiments with each experiment having its:

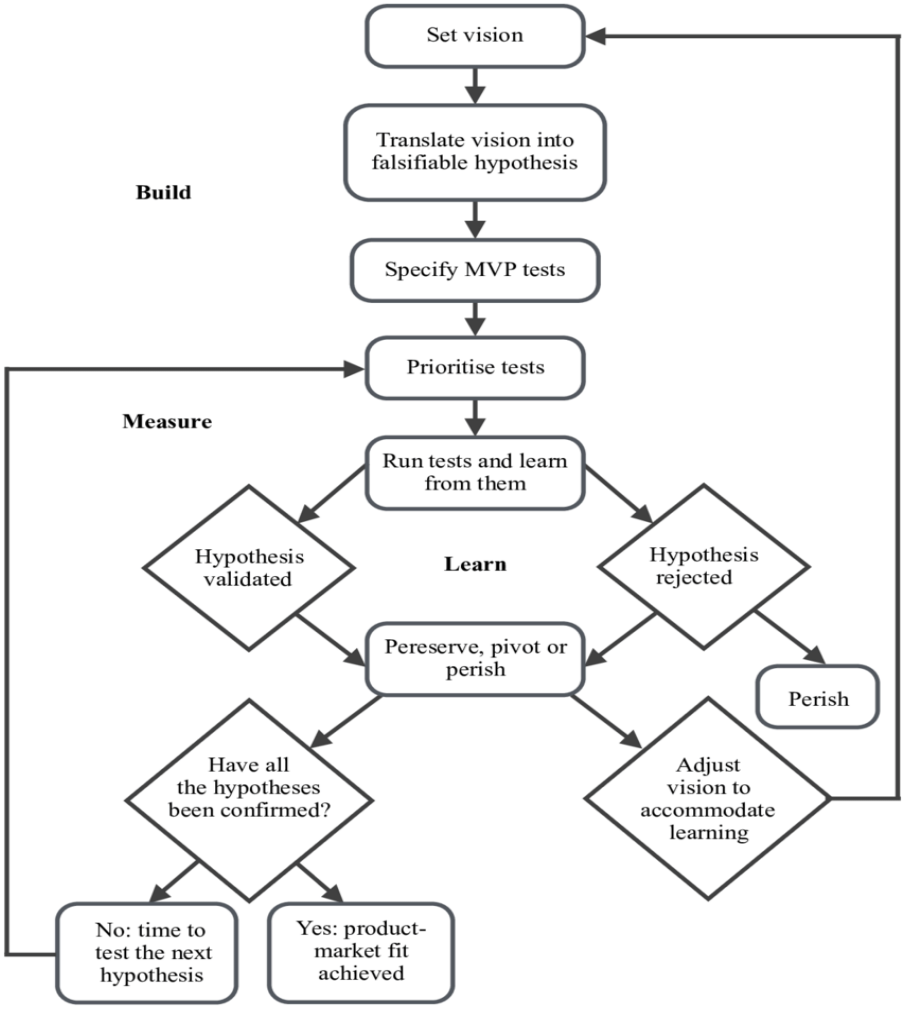
1- MVP: minimum viable product, usually an incomplete version of the product to be built incrementally.
2- Hypothesis: what is supposed assumed to be true and/or in need of verification.
3- Indicators: how to measure whether the hypothesis is confirmed or denied.

This cycle of building, collecting data, and analyzing it to improve is called the *build-measure-learn feedback loop*.

Should the result of the experiment be positive, a decision of continuing on course or preserving is taking. If the experiment demonstrates that the hypothesis is wrong, modifications are made, and follow up experiments are conducted. If the changes are large such as those in the business model, they are called *Pivots*. If all the assumptions are wrong, then the project is abandoned.

The relevant steps for the Build-Measure-Learn steps of framework application are shown briefly in the figure below.

Figure 6: The Lean-startup methodology process steps



(Adapted from Eisenmann et al., 2012:3)

Innovation accounting

As the methodology embraces continuous improvement and the release early and often principles, the product might have multiple MVPs, and each one can be more complicated than the previous. Even after arriving at the beta and alpha release, the product is not considered finished as the goal here is to derive more customer satisfaction and more growth with each experiment; as such, Ries (2011) proposes his system of progress measurement called innovation accounting and defines it as a way to evaluate progress when all financials are zero or haven't yet arrived after the particular modification had been deployed.

Ries splits the application of the Innovation accounting framework on three levels:

1. Dashboard: which contains per-customer metrics related to the business plan's assumption without dwelling much into costs.

2. Business Case: indicators that trace the steps in the customer's journey as well as related costs and growth engines.
3. Net Present Value: translates the learning generated from pervious metrics into financial indicators of performance to see the concrete impact of each experiment.

2.3. Stage-Gate

Originated by (Cooper, 1990b) and can be said to be adopted from the genera of decision stage model[11] (Cooper, 1990b, p. 438; Trott, 2012; Saren, 1984), the original version of the stage-gate model has five stages and five gates with costs increasing from each stage to the next.

The reasoning of this process model is that products concepts are not allowed to pass through the gate to the next stage of development unless the deliverables are judged to be good enough by the gatekeepers, those are senior managers who are multifunctional and multidisciplinary and are responsible for screening "scrutinizing" the project at each gate and are able to give one of four decisions Go/Kill/Hold/Recycle.

Original phases

The following elements constitute the original steps of the process

Table 2: Stage gate original phases

Stages	Deliverables and activities
Ideation:	Ideas are submitted to Gate 1. If approved, they move to the preliminary assessment.
S1: Preliminary assessment	Business needs statement Market Size, Potential, Likely customer acceptance Development and manufacturing feasibility Simple costs and timeframes.

[11] Decision stage model: "Decision-stage models represent the new product development process as a series of decisions that need to be taken in order to progress the project." (Trott, 2012)

S2: Business case	Customer needs, wants, preferences. Concept testing. Detailed Technical assessment. Legal and patent-related considerations. Finance: discounted cash flow and sensitivity analysis.
S3: Development	Product development. Test, Marketing, and operations plan. Updated financial analysis. Patent and legal issues resolution.
S4: Testing and Validation	Activities such as user field trials in house trials. Pilot plant production. Trial sells.
S5: Commercialization	The full-scale launch of marketing and operations plan.

Adopted from (Cooper, 1990b, pp. 9–10)

Gates

Following each gate is a special review conducted by the mentioned individuals; the review gets stricter as the project moves along the gates due to the amount of investment needed. Gate 1 is considered a soft gate, and even stage 1 itself has a relatively shorter timeframe, gate 2 approves a more detailed analysis of the project in preparation for gate 3.

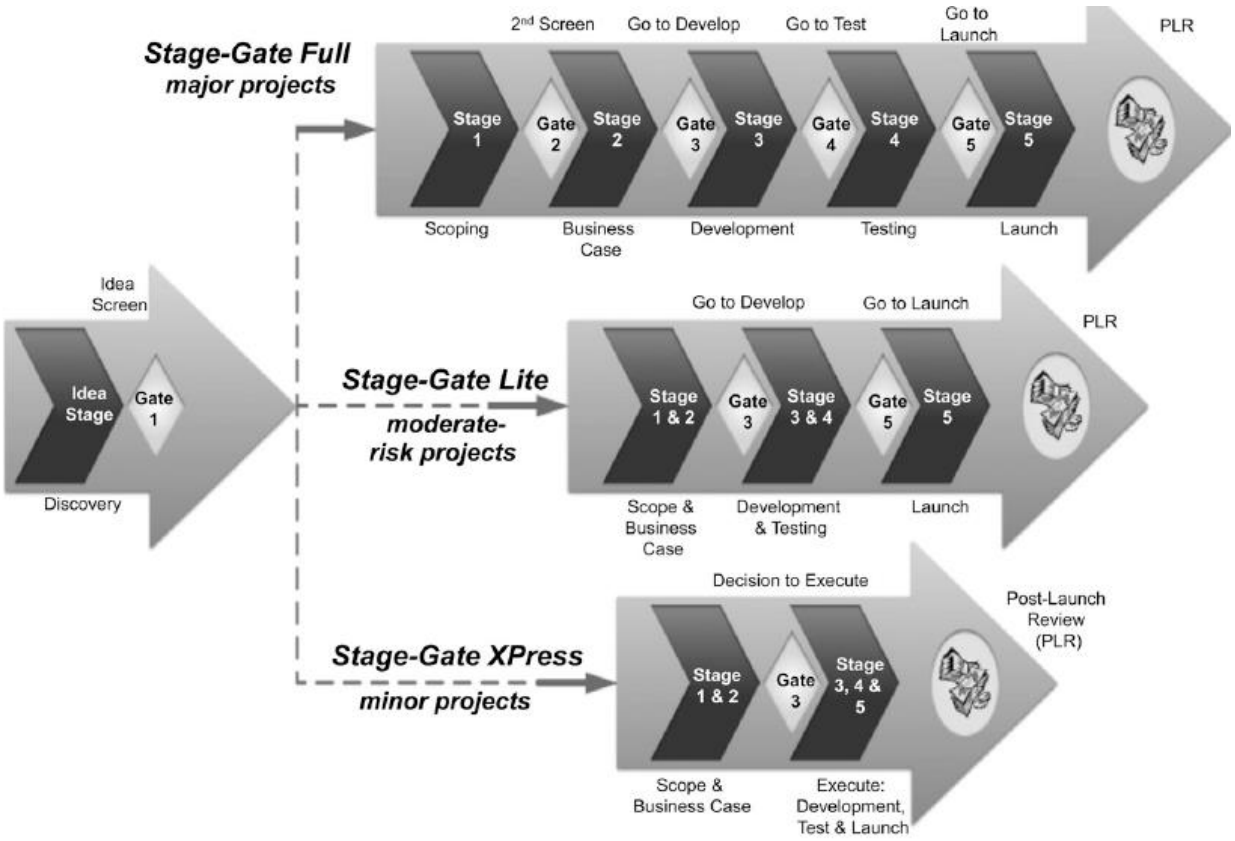
Gate 3 approves or disapprove of the project going into the expensive development; gate 4 is the post-development review questioning the economic aspects of the project as more data is available, the plans for testing, marketing, operations are reviewed.
The pre-commercialization review looks at the activities of validation, their results, and the financial projections.
After implementation, comes the post-implementation review, where performance measurement is conducted and where the product project becomes a regular firm's product. This is an opportunity to check for project team results to try to better the process in the future.

Criticism and New trends

Critics of the stage-gate model argue that it is somewhat slow with an over-focus on end gates rather than customers, which can get worse in the case of poor management, in addition to the early abandoning of product concepts. For these reasons, Trott (2012) considered it unsuited for the uncertain nature of NPD.

As to address these critics, Cooper (2014) proposed subsystems that are, to his claim, Adaptive, Agile, and Accelerated with the ability to overlap stages and stage activities focusing more on the fuzzy front end. The mentioned systems are demonstrated in the figure below.

Figure 7: Scalable Stage-Gate systems



From Cooper (2014)

2.4. Agile NPD

Origin in software

Originally coming as a replacement to the waterfall programming process, it makes sense that most of the research done on Agile focuses on software development (*Olsen,2015*). Frameworks related to software have been developed, with each taking inspiration from the principles of agile; those include: self-organizing teams, continuous improvement, customer satisfaction through early and continuous deployment.

Known frameworks include Feature-driven development, flexible product development, extreme programming, Kanban, and Scrum (Visser & Selnes, 2017), with the latter being the most popular framework (*Olsen, 2015*).

Scrum is also considered viable for physical product development (Visser & Selnes, 2017), which is why it was chosen to add in our comparison.

Three primary roles are included in the framework

- *Product owner:* Who represents user interests and is in charge of constructing what is called *user stories*[12] from feedback gotten and collecting them in a prioritized *product backlog*[13].
- *Scrum master:* Whose goal is to improve the performance over time as well as help the teams with the process.
- *Development team: They* should be constructed of multidisciplinary members, the sum of which is sufficient to complete the product.

Process

After creating and refining the product backlog, a sprint planning meeting at the beginning of the sprint is conducted. The team decides which user stories to accomplish during the relevant iteration, called sprint backlog.

The goal of each sprint is the arrival at a potentially shippable product. Fifteen minutes daily, meetings called ***standups*** are held up before work start to plan the day, and at the end of each

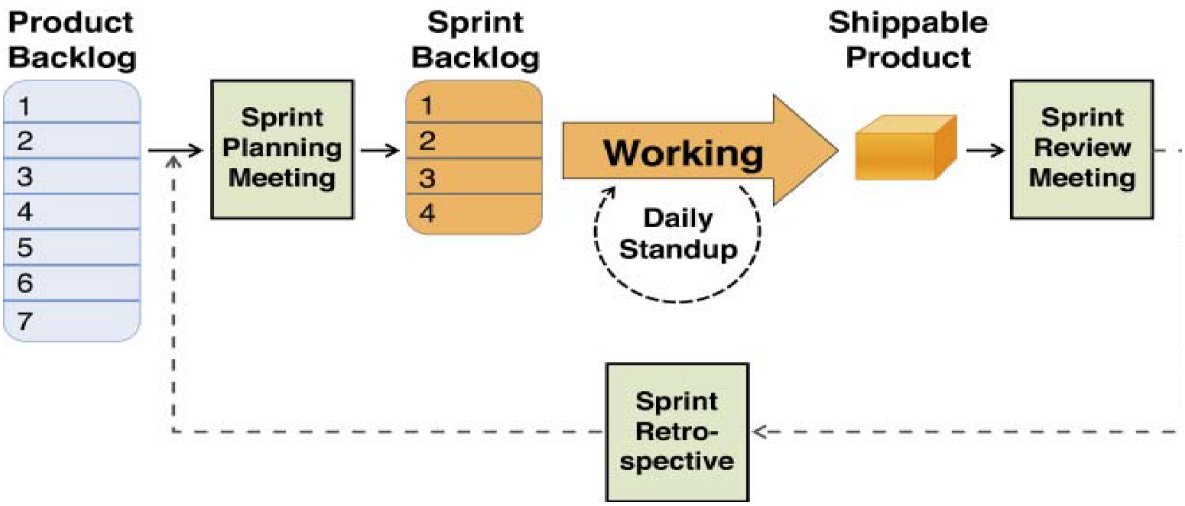
[12] User stories: "A user story is a high-level requirement that has just enough detail to allow developers to produce a rough estimate of its size. It should represent something between a half-day and two weeks of work." (Cohen, 2010)

[13] Product backlog: "A list of requirements and features, often written as user stories, prioritized by business value." (Cohen, 2010)

sprint, a sprint review meeting is held to show the resulting product to the team, exposing them to their progress.

A sprint retrospective meeting is held after a sprint or two to improve the next sprint based on what works and what was a mistake. The process is made clear by the figure below.

Figure 8: Scrum Framework



From Olsen (2017)

2.5. Design thinking

According to *Michael G. Luchs, Scott Swan, Abbie Griffin, (2015*), design thinking is: *"A systematic and collaborative approach for identifying and creatively solving problems."*
Similar to Lean-startup, design thinking advocates generating simple prototypes and iterating one's way to improvement, this approach, however, was originated long before Lean-startup but it was further developed and brought to the mainstream view by consulting agencies such as IDEO and schools such as Stanford design school.

Contrary to the previous approaches, design thinking puts special empathizes on the ideation phase making it more accustomed to treating the fuzzy front end side of NPD (*Luchs,2015)*.
As Lean-startup, customer development, and Agile, design thinking works in iterations or cycles with the goal of developing radically innovative solutions.
Liedtka (2017) suggests that the impacts of using design thinking include improving solution quality and reducing innovation risk.

Process

1. **Empathize:** as the word suggests putting oneself in the person's view, meaning getting a thorough understanding of customer's needs, both obvious and much importantly, hidden ones, this is made possible through qualitative methods of interaction but also through immersion in the customer's experience.
2. **Define:** The step of formalizing the data gathered in a clear, explicit problem statement(s)[14].
3. **Ideate:** Here, radical design ideas are generated through brainstorming coming up with multiple concepts.
4. **Prototype:** A very similar preceding concept of the Lean-startup's MVP in which low (ex: paper interfaces) and high resolutions (digital mock-ups) designs are prepared and that the customer can interact with.
5. **Test:** putting the mentioned prototypes in the hands of potential customers and observing the interaction to be able to improve.

Undertaking design thinking necessities, the acceptance of multiple principles such as:

- Innovation is made by humans for humans: the abolishment of *Eureuca moments* as the only circumstances in which generating innovative ideas is possible.
- Fail often and early. It is expected and accepted that early prototypes and or ideas might not be a good fit, so iterations are necessary.
- Build prototypes to be experienced, highly useful data can be generated through observing and experimenting with user feedback.
- Design never ends, etc.

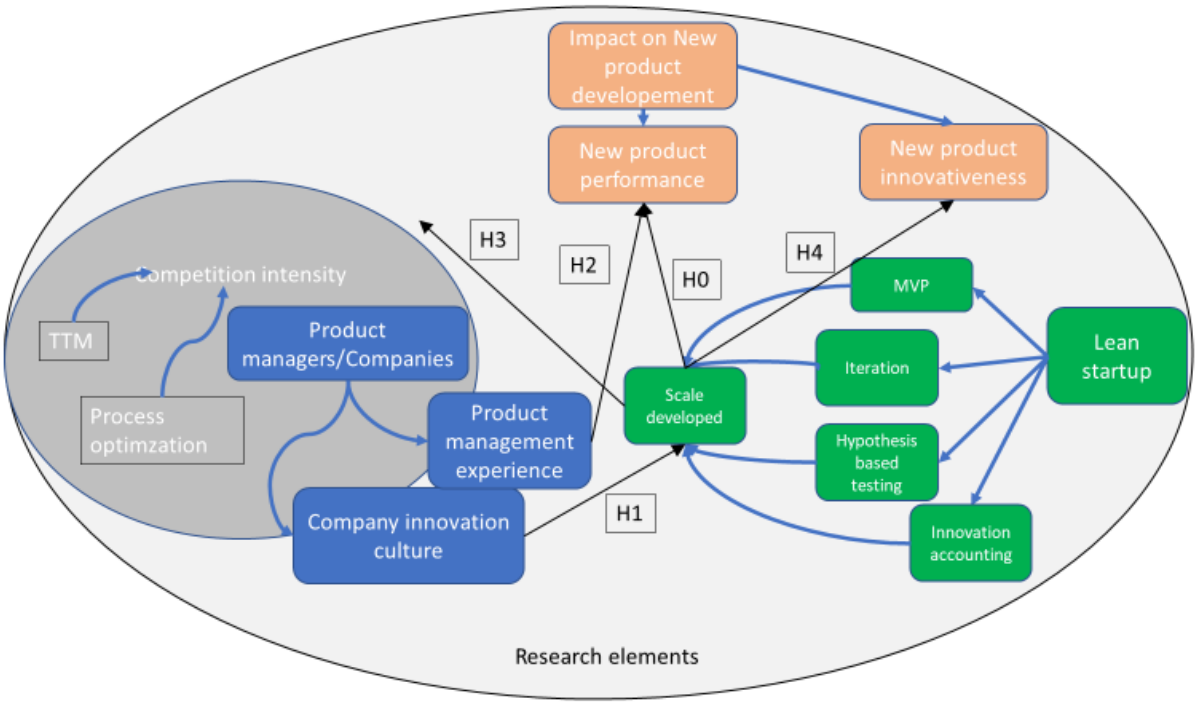
3. Summary

From the previous literature review, we find that Lean-startup combines many of similar approaches as a means to provide a framework for product development beyond the limitation of software and to explicitly counter uncertainty.

[14] Problem statements: "generally are short statements that describe the customer type, an unaddressed need, and the insight that explains why the identified need is especially worthy of addressing" (Luchs et al., 2016)

The lack of deliverables might make the framework hard to implement successfully, but that is, in our view, compensated by the wealth of tools available. Besides, as Ramm (2015) found , tech firms tend to combine many frameworks as a way maybe to get the best out of each one and maximize performance. Whether this framework would have direct implications on the new product development will be explored in the rest of the dissertation as the research model below shows

Figure 9: Research model



Made by ourselves using PPT

As the theoretical framework helps in giving an overview of new product development, its key concepts, and Lean-startup characteristics, the next step would be to operationalize those concepts in a way that makes answering the research question feasible.

As such, two characteristics were chosen to base the impact on which are: product innovativeness and product performance in addition to environment and respondent related variables such as company innovation culture and product management experience.

For the Lean-startup construct using the elements from the literature review, a scale will be corrected for representativity, validity, and reliability.

Chapter 2: Methodology

In order to address the research question that aims at knowing ***the impact that Lean-startup has on new product development*** initially, a case study approach was planned with the acceptance of the first planned hosting firm "Algerie poste" to work on its new service. However, that came to a halt due to the Covid-19 outbreak, so a choice was made to do a quantitative study through a survey with product practitioners.

1. Methodology and Epistemology:

Since Lean-startup is considered well known in the global context and since survey participants were not limited to Algerians, but the emphasis was on choosing product managers, a quantitative study seemed more appropriate to investigate it, as quantitative study design *"Allows for a broader study, involving a greater number of subjects, and enhancing the generalization of the results"* (Research Guides: Organizing Your Social Sciences Research Paper: Quantitative Methods, 2010).

An additional argument for this approach is that product managers who take into consideration field circumstances would take great care into ensuring the best outcomes for their products and thus be inclined to using the best available methods and processes. This also justifies the use of a descriptive approach that assesses the relationship between the variables without influencing them.

Quantitative research follows a positivism type epistemology, so an effort to minimize researcher's view and interpretation was conducted through operationalization of all the variables to be used in the survey; this was done through the use of verified scales for most variables and a scale that was both pre-verified and post-verified for Lean-startup.

1.1. Relation to previous research

Previous research on Lean-startup used at times qualitative methodology (J.A. Casselman, 2016), mixed methodology (Patz, 2013), only one dissertation was found with purely a quantitative methodology (Ramm, 2015); short experimental cases do exist as well (Nirwan & Dhewanto, 2015).

One limit to Ramm (2015) was not being able to know what positions responded to the survey, so to overcome that, the search for participants concentrated on them having product management-related careers. Previous research also had the limit of the absence of a

guarantee that respondents will answer with what they do in the real world; instructions were added to inform them to respond based on previous experience.

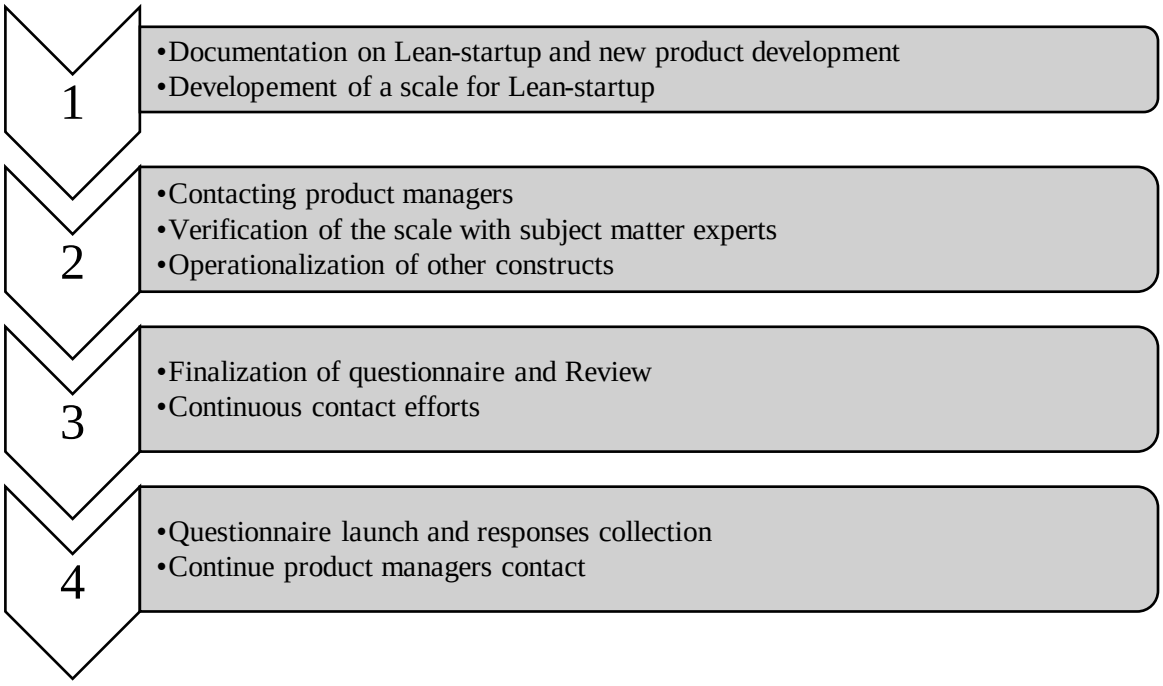
1.2. Nature of needed data:

In order to calculate the correlation between the different variables, quantitative data was needed, so the majority of variables used a 5 point Likert scale, and the verification of content validity was done through a quantitative 4-point Likert scale data provided by the experts contacted, however in order to fill the gap in the representation of Lean-startup components two additional questions asked for qualitative data A11 and A12 that were later converted into a score and added to the Lean-startup variable.

For data collection, potential respondents were contacted through linked in one month before the survey was launched to collect emails; after sending the form to them, a low turnout was noticed, so a reminder on both email and linked in messaging was sent after two days. Additional product managers were contacted after the survey has been published, which increased turnout.

1.3. Timeline

Figure 10: timeline of the research



Made by word

As we can see in figure 10, the research started by conducting a literature review on Lean-startup research and new product development generalities before proceeding to the development of the corrected scale for Lean-startup

1.4. Hypotheses

To answer the previously mentioned research question, a set of hypotheses were prepared

H0) Lean-startup use does not significantly affect new product success.

A company might use several techniques in trying to become more productive and achieve its objectives, that was one of the results of Nilsen & Ramm (2015), so the company culture might impact new product development by providing a fitting environment for Lean-startup or other techniques to flourish, to investigate that, H1 is stated as follows:

H1) Company innovation culture might correlate positively with Lean-startup adoption

Patz also found out that experience in entrepreneurship correlates with company success, in order to provide some insights on the generalization of that to product management H2 is stated.

H2) Experience in product management is related to new product success

As the study involves product managers from multiple countries, a measure of the competitive environment could offer a possibility to generalize some results, so the following hypothesis is stated:

H3) Highly competitive environment may tend to adopt Lean-startup more than others.

An alleged quote by Henri Ford that critics against too much customer feedback use is “If I had asked people what they wanted, they would have said faster horses.” While there is little evidence that Ford actually said that, the argument does exist that advanced science products have little room for experimentation with customers financially and technically speaking. Hence, the following hypothesis aims at investigating this possibility.

H4) The more innovative a product, the less likely Lean-startup would be used.

2. Data collection tools

2.1 Lean-startup expert evaluation survey

After forming the Lean-startup scale and adapting it to the study, the relevant statements were formed into a survey; six experts in Lean-startup were asked to participate in short 30 minutes guided interviews to grade the questions on a 4-point Likert scale from not relevant to relevant. Or what is called content validity index analysis.

Three experts responded in time, which is the minimum to conduct the analysis. As a result, we had one metric to grade our Lean-startup scale for validity in addition to Cronbach's alpha for inter-item reliability.

This adds to the original tool as it was not corrected, or the correction was not documented for content validity using this method.

2.2 Questionnaire

In order to capture as much as possible external factor's influence, questions that measure or contribute to product success scales for respondent's experience, company innovation culture, product innovativeness, competition intensity were introduced in addition to the primary variables of Lean-startup use and new product success

Nilsen & Ramm (2015) survey was used as a basis for the questionnaires, with modifications such as removing the statements about entrepreneurship theories, company success, modifying the Lean-startup and experience variable, and adding the set of variables mentioned above.

Before passing the survey, respondents had to answer a filter question that, in addition to the profession question, enabled us to have only those in a product management career responding. Once the respondent chose at least one product management responsibility, he/she was allowed to continue.

The survey was split into five primary sections preceded by a context-specific section containing personal and general company information; the five sections are organized as follows:

Section A: Product management statements.

Here the 12 statements related to Lean-startup adoption were mentioned after asserting their relevance and the modification. The statements provide a representation of Lean-startup components and principles and offer the respondent a choice to be in line with them or against them in a point Likert scale. Some questions used reverse scales; others are based on entry data analyzed after collection to be given a score.

Section B: Company environment.

This section contains statements related to company culture and aims at measuring if it can foster innovation according to the mentioned Denison (2006) scale. Combining it with company size and age will allow us to determine if innovation culture is related to them.

Section C: Intensity of competition.

As the name entails, this section aims at measuring the competition level in which the relevant company lives through 6 items and will be used to measure whether Lean-startup adoption increases when competition increases

Section D: Work experience.

Experience in product management using four items is measured here, to measure the influence of work experience on product success and if the item for time-scale measurement correlate with more detailed ones measuring how many workgroups, products, features the relevant product manager did work with or on, in other words, is a timescale measurement an accurate predictor of product performance

Section E: Performance of a new product.

The respondents were asked to think about a product they managed in order to assess the profitability, performance, and innovativeness to get the product's performance and the product innovativeness variables.

3. Measures

To answer the hypothesis, several independent variables were adapted from different scales in research.

3.1 New product performance

The company's success variable in Ramm (2015) considered elements that are not generalizable in the Algerian ecosystem as well as information that might be critical for some respondents ex: (sales amount, the reception of funding, and the firm’s valuation). In addition

to that, the variable does not address product performance nor NPD success, and so it was dropped, and other scales were adopted.

Multiple scales were found to assess new product success. For example, Ettlie (1997) measured it by two subjective multiscale items: commercial success, which is related to meeting expectations, ROI and market share, and technical success or the achievement of the project under specification.

The scale adopted was the Relative New Product Success from Song & Parry (1997) research. It was used to measure the overall NPD Project Performance in Ernst et al., (2010), and it consists of four 7-point Likert scale statements, an alteration to a 5-point scale was done to ensure homogeneity. The original scale found a Cronbach's α of .90.

3.2 Lean-startup adoption:

The Lean-startup variable in Ramm (2015) consisted of a series of statements quantified using 5-point Likert scales, two questions, and some statements were added. However, the majority of said statements were adopted except for the following three:

- "Instead of doing market research, you should go try to sell your product."
- "Market research is more valuable than experiments with customers."
- "On average, people who start companies are fundamentally different from people who do not."

The first and second statements suggested that the notion of *"Trying to sell the product" or "experiments with customers"* two notions originally from the customer development model (Bank, 2004) are a replacement to market research in Lean-startup. As mentioned before, the customer development model is one of the cornerstones of Lean-startup. It wasn't proposed to substitute product development but as a parallel process to it. Blank also mentions that a market opportunity analysis is a preferable first step for idea screening in his online course. Two questions that ask about Lean-startup techniques and actionable metrics were added instead to fill the gap in variable representation.

3.3 Company innovation supporting culture:

To assess the company's flexibility to try new methods and how important to it translating customer needs to its products, this variable was added and measured by the 3rd component of the Denison model for company culture (Denison & Janovics, 2006).

More precisely, two sub-components of the adaptability scale were adopted, “the ability to create change” statements in addition to those that measure “organizational learning.”

3.4 Competition intensity:

To answer H4 and assess whether the environment's competition intensity pushes the company to adopt new methods, more particularly Lean-startup, a variable was added.
The scale used was adapted from Jaworski and Kohli (1993) that uses six items with a 5-point Likert scale to measure competition intensity. According to the literature review done by Kwieciński (2017), it is the most frequently used scale to measure it.

3.5 New product innovativeness:

For product-related variables, one setback was choosing the product to measure success or innovativeness. To avoid the researcher’s bias, the respondents were asked to answer with a new product in mind that was developed and launched in the last five years.

To measure whether product innovativeness impacts the use of experimentation, we chose the Moorman’s new product creativity scale from Moorman (1995) as it was used in other research to measure product innovativeness (Fang, 2008), it measures the novelty of the product and if it brings new ideas. Three items of the scale were adopted with a 5-point scale instead of a 7-point one for the same previous reason.

3.6 Product management experience

Nilsen & Ramm (2015) measured experience by a Time-based measure using the number of years in entrepreneurship, this type of measure is criticized by Shackleton (2016) for not having the same impact on performance for all employees and not taking into account the different contexts in which a job was done. In addition to that, time scale measurement using a cumulative number of years was found to be a poor indicator of experience in the same research.
Two measures were found to have a strong correlation with the experience construct one is the number of organizations and the number of workgroups or teams in which the target job was performed (Shackleton,2016), so to answer H2, two questions were introduced that mimic that for product management in addition to a timescale measurement.

3.7 Use of process models

In the previously mentioned survey, Nilsen & Ramm (2015) added one section dedicated to familiarity with the different entrepreneurship theories to find out if claimed familiar theories are being applied. A different objective was undertaken to assess at what stage of product development are different process models used to visualize responses in a diagram as see the scope in which each process model is used.

Two models were added concurrent engineering and design for six-sigma to avoid as much as possible non-selection bias.

4. Population and sampling

The responsibilities of handling a product development process in established companies belong to product managers, who take charge of product planning, development, and launch. Early company's CEOs can take the responsibilities of product management.

In order to have insights from practitioners who are faced with decisions of choosing between practices continuously to solve problems and optimize solutions, the search concentrated on those in the product management careers.

For our sampling, we opted for a convenience type of sampling through Linked in search, as well as a snowball sampling in which we asked each respondent to provide two emails of someone he felt could offer useful insights.

About 800 individuals were contacted, 47 provided their emails, and some preferred to be sent the survey through linked in. In addition to that, the snowball method provided about six additional emails

During the email sending phase, the first batch of 47 emails yielded about 20 responses, so the effort of contact continued until reaching a sample size of 40, several responses were deleted due to repetition or incomplete information.

5. Data analysis

To minimize confirmation bias Ramm (2015) avoided entrepreneurs famous for using Lean-startup, in addition to that a focus on general statements that put the respondent in a position choose between being in-line with Lean-startup principles, against them or indifferent to them were used as to avoid the influence of respondent's personal view or his/her understanding of the framework.

The general statements measure was also undertaking with an additional measure of whether or not they are relevant to Lean-startup through the content validity index method. Following the data collection, most items being Likert scale type statements were quantified on a scale from 1 to 5. The two questions A11 and A12 were converted using other criteria as follows,

A11. Mention 3 key metrics you continually monitor to judge performance in your latest product project.

Questions A11 asks the respondent to mention three key metrics are used to measure performance and was graded on a scale from 0 to 2 by comparing responses to those sub-questions:

- *Does the metric offer insights on customer behavior, or is it a purely financial indicator?*
    - *If yes, the grade was 1*
    - *If two or three indicators correspond to the criteria, the score assigned was 2.*

The argument for choosing these criteria was inspired by Ries (2016) as he defined innovation accounting as a way to measure progress when financials has not arrived yet. The section of the book called innovation accounting also mentioned that it aims at figuring out causes for customer behavior by analyzing it.

A12. Which of these, if any, are techniques you used: [Cohort analysis; Split testing A/B testing; Low/high fidelity prototypes; Iterative development; 5 Why (or root cause) analysis; Customer interviews.]

- If 1 or 0 techniques are used, the score assigned was 0

An application of one technique accidentally or in the midst of using other methods can happen ex: for those using Agile scrum methods, iterative development is an obvious adoption.

- If two techniques are used, the score assigned was 1
- If three or more techniques are used, the score assigned was 2

After data preparation, an analysis was conducted using the software IBM SPSS. The latter was used to assess the internal validity of the scales as well as the survey as a whole and to calculate the different correlations and linear regressions.

Chapter 3: Results and discussion

A presentation of research results is made here. First, we proceed with data reliability and validity analysis, then the analysis using descriptive statistics, bivariate analysis, and linear regression.

1. Presentation of research terrain

Yassir SPA is an Algerian startup in the transportation sector. Founded in 2016, its services were only restricted to taxi booking in Algeria. However, currently, it offers B2B services, general delivery, food delivery services, and continuous improvements with new features in its mobile applications.

It is currently present in multiple countries such as Morocco, Tunisia, France and recently joined the most famous startup accelerator in the USA called Y combinator.

Yassir is working on new technologies for the Algerian market and the others, which makes it really relevant for a theme in new product development, especially that they already employ a version of Agile development. According to its Linked in page, employee number ranges from 51-200, it recently closed down a new product due to low turnout which makes the theme even more interesting for the company

2. Reliability and validity

Since the Lean-startup scale was the only one that had embedded modifications as supposed to the other more established scale, the reliability and validity assessment was focused on the statements regarding Lean-startup use.

2.1. Validity

To establish face validity, the final form was shown first to one product management expert with 12 years of experience over a zoom call, and a quantitative research expert for their feedback prior to being launched.

2.2. Content validity:

The content validity index for individual items (I-CVI)[15] and the scale (S-CVI)[16] was calculated by online interviews using a form as an interview guide with three Lean-startup experts, one of whom is a member of Leanstartup.co, a world-renown authority on Lean-startup which co-founded by the author himself Eric Ries.

[15] I-CVI: Content validity index for individual items.
[16] S-CVI/UA: Content validity index for the scale/Universal agreement.

These experts were asked to rate only Lean-startup questions and statements on a 4-point scale from not relevant to Lean-startup principles.

Table 3: Designation of experts on Lean-startup

Role	Organization	Experience with Lean-startup
Mentor	Leanstartup.co	8
Consultant	TribuGift	7
Mentor	*ANCF(Association National des Conférenciers Français)*	7

Made by word

Table 4: Lean-startup items assessment

Lean-startup Items	Expert 1	Expert 2	Expert 3	Number of agreements	Item CVI
A1	X	X	X	3	.92
A2	X	X	X	3	1
A3	X	X	X	3	1
A4	X	X	X	3	.83
A5	X	-	X	2	.75
A6	X	X	X	3	.92
A7	X	X	X	3	.92
A8	X	X	X	3	.92
A9	X	X	X	3	1
A10	X	X	X	3	1
A11	X	-	X	3	.83
A12	X	X	X	3	1
Proportion Relevant	1	.83	1	S-CVI/Average = .92 S-CVI/UA= .97 Mean expert proportion= .94	

(X): 3 or 4 relevant.

(-): 1 or 2 not relevant.

Made by ourselves using Excel

The Scale Content Validity index is the average item's CVI. To convey content validity, researchers recommend that the scale's S-CVI/Average should at least be .80 (Shrotryia & Dhanda, 2019)

2.3. Reliability

The Cronbach alpha's factor for the entire questionnaire minus the experience items as they were open-ended questions and thus presented large discrepancies, yielded a value of α = .804, which is considered "very good" as such, the questionnaire as a whole is considered reliable.

After that, the estimation of reliability for the different scales was conducted and are presented bellow

Lean-startup:

For the Lean-startup adoption variable, the initial 12 item scale yielded a weak result of α = .676, using the options scale if item deleted, different combinations were used in order to arrive at a more reliable alpha the chosen scale to continue the analysis with was the use of 9 items with the statements A1, A2, A3 removed, the scale as mentioned in Table 5 yielded a value of α = .711 which makes it a reliable measure from an inter-item reliability perspective. In addition to that, it has an S-CVI/Average value of .91, which is considered good for content validity.

Table 5: Inter-Item reliability and content validity Lean-startup

Different scales	Cronbach's Alpha	Mean CVI for comparison
12 items scale	.594	.92 > .8
9 items scale (A1,A2,A3 removed)	.711	.91 > .8
8 items scale (A1,A2,A3,A6 removed)	.725	.90 > .8
6 items scale (A4,A5,A6,A7,A9,A11,A12) kept	.634	.89 > .8

Made by ourselves using SPSS

Following that, an attempt to reduce the number of items into a representative value was conducted using the mean for the nine items.

Table 6: Lean-startup adoption correlation table with Lean-startup items

Lean-startup adoption	Items	A4	A5	A6	A7	A8	A9	A10	A11	A12
	Correlation coefficient Spearman's rho	.724	.586	.348	.660	.385	.623	.412	.668	.460
	Sig.(2-tailed)	.000	.000	.028	.000	.014	.000	.008	.000	.003

Made by ourselves using SPSS

We notice that the items have a strong significant correlation to the variable chosen to represent Lean-startup adoption.

Product innovativeness

Upon calculating Cronbach's alpha for the six items scale of innovativeness value of $\alpha = .848$ was found, meaning that the scale has strong inter-item reliability, as done previously, reduction of items was used for easier analysis using the mean of the six items

Table 7: Cronbach alpha score for new product innovativeness items

	Cronbach's Alpha
6 items scale E4-E9	.848

Made by ourselves using SPSS

Table 8: New product innovativeness correlation table with product innovativeness items

	Items	E4	E5	E6	E7	E8	E9
New product innovativeness	Correlation coefficient Spearman's rho	.792	.698	.943	.863	.498	.481
	Sig.(2-tailed	.000	.000	.000	.000	.001	.002

Made by ourselves using SPSS

All items show a significant correlation to the average, which justifies its use as a score for innovativeness.

New product performance scale

The value of Cronbach's Alpha between the three items of the subjective scale for new product performance shows strong inter-item reliability with a value of $\alpha = .792$.

Table 9: Cronbach's alpha score for the 3 item scale of new product innovativeness

	Cronbach's Alpha
3 items scale E1-E3	.792

Made by ourselves using SPSS

To reduce the number of items, the same previous procedure was done by calculating a new variable using the mean of the three items. All three items show a strong positive significant correlation with the mean.

Table 10: New product performance score correlation table with product performance items

New Product performance	Items	E1 Success from an overall profitability standpoint	E2 Success in terms of revenue relative to other new products	E3 Success in terms of profits relative to the firm's objectives
	Correlation coefficient (Spearman's rho)	.864	.783	.785
	Sig.(2-tailed	.000	.000	.000

Made by ourselves using SPSS

Competition intensity

The six-item scale for competition intensity showed weak inter-item reliability; thus, it was reduced to a 4-item scale with C1 and C6 deleted the new value of $\alpha = .678$, which is considered acceptable.

Table 11: Cronbach's alpha score for the scales of competition

	Cronbach's Alpha
6 items scale	.605
5 items scale (C6 deleted)	.661
4 items scale (C1 and C6 Deleted)	.678

Made by ourselves using SPSS

Dimension redaction was also conducted using the mean, and all four items correlated with the mean with sufficient value.

Table 12: Competition intensity score correlation table with competition items

Competition intensity	Items	C2	C3	C4	C5
	Correlation coefficient Spearman's rho	.731	.762	.706	.621
	Sig.(2-tailed	.000	.000	.000	.000

Made by ourselves using SPSS

The chosen competition score has a strong significant correlation with the four competition items, which eliminates the need for further correction.

Innovation culture

The innovation culture 10 item scale was found to have strong inter-item reliability with a value of $\alpha = .868$.

Table 13: Cronbach's alpha score for the scales of Innovation culture

	Cronbach's Alpha
10 items scale B1-B10	.868

Made by ourselves using SPSS

3. Demographics:

Here, we present the demographic information of our respondents and the context of their company followed by a small discussion. This helps to understand the scope of our study as well as better understanding its results.

Table 14: Demographics of respondents.

Measure	Modality	Frequency (n)	Frequency (%)
Gender	Male	29	72.50
	Female	11	27.50
	Total	40	100.00
Age (years)	Below 25	1	2.50
	25-35	28	70.00
	36-45	10	25.00
	More than 50	1	2.50
	Total	40	100.00
Country	Algeria	9	22.50
	UK	8	20.00
	USA	5	12.50
	Germany	6	15.00
	The Netherlands	3	7.50
	France	2	5.00
	Nigeria	1	2.50
	Other *countries**	6	15.00
	Total	40	100.00
Company *size (number of employees)*	1~45	9	22.50
	50~249	8	20.00
	More *than 250*	23	57.50
	Total	40	100.00
Company *age (years)*	Less than *a year*	5	12.50
	1~5	10	25.00
	6~10	2	5.00
	11~15	9	22.50
	More *than 15*	14	35.00
	Total	40	100.00
Industry	Automobiles and *components*	1	2.50
	Capital goods	1	2.50
	Commercial and *professional services*	2	5.00
	Consumer services	1	2.50
	Diversified *Financials*	1	2.50
	Energy	1	2.50

	Healthcare *equipement and services*	1	2.50
	Materials	1	2.50
	Media	1	2.50
	Pharmaceuticals, biotechnology and life science	4	10.00
	Consumer staples	1	2.50
	Retailing	2	5.00
	Software and services	14	35.00
	Technology hardware and equipment	5	12.50
	Transportation	2	5.00
	Telecommunication *services*	2	5.00
	Total	40	100.00
Occupation	Product manager	21	52.50
	Senior product manager	10	25.00
	Product owner	2	5.00
	Senior director of product management	1	2.50
	Chief R&D officer	1	2.50
	Other related occupations**	5	12.50
	Total	40	100.00
Educational *background*	Entrepreneurship	2	5.00
	Economics	3	7.50
	IT	14	35.00
	Natural *science/ Engineering*	7	17.50
	Marketing	6	15.00
	Business	8	20.00

Made by ourselves using Excel

Other countries*: Morocco, Nigeria, Saudi Arabia, UAE, Egypt

Other related occupations**: Brand manager, Chief Product Officer, Director of Business Development and Payment Strategy, Head of Product Management, Product Development Manager.

3.1. Commentary:

Occupation: most of the respondents were indeed from a product management career, which is the intended population except for a one or product owners, but since they answered the filter question, their responsibilities should be linked to that of product managers.

Location: the countries of those who responded the most to our invitation to fill out the survey were in order; Algeria, UK, Germany, and the US together they constituted 70% of responses.

Educational background: most respondents are from an IT background even though the role is heavily related to market insight followed by natural science/ engineering, business, and marketing majors, that might show the popularity of hiring those with multiple skillsets into that role.

Industry: the three leading industries in responses are in order: software and service, technology, and pharmaceuticals; the survey was, as mentioned before, conducted over a variety of fields in the search for a common tendency.

Company age: almost 50% of companies participating have been founded before eleven years; this could be due to the fact that the responsibilities of product management are taking on at when the company is starting out by the founding team and the CEO, which will make for a weak representation of product managers percentage in those companies. However, 15 companies founded in the last five years have participated, which could indicate that they grew enough to establish product roles and, therefore, an indication of the relevancy of results.

4. Univariate analysis:

Here we present an analysis using descriptive statistics as well as tests of normality for the different variables.

4.1. Lean-startup:

Table 15 below shows the descriptive statistics for Lean-startup adoption to better understand the representation of the variable in the sample.

Table 15: Descriptive Statistics for the Lean-startup adoption variable

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Lean-startup adoption	40	2.56	1.78	4.33	3.19	.62

Valid N (listwise)	40

Made by ourselves using SPSS

From it, we notice that the range of adoption varies around a mean of about 3.2, which is close to the middle value of 3, taken with the standard deviation of almost .62 that indicate that 95 % of results are contained between 2σ from the mean, meaning between 2 and 4.2. This might indicate that for the majority of companies, components of the Lean-startup framework are used but usually not all of them at once. It could also mean that some items are redundant and need to be revised through another tool, such as a PCA analysis.

Test of normality:

Table 16: Tests of Normality for Lean-startup adoption

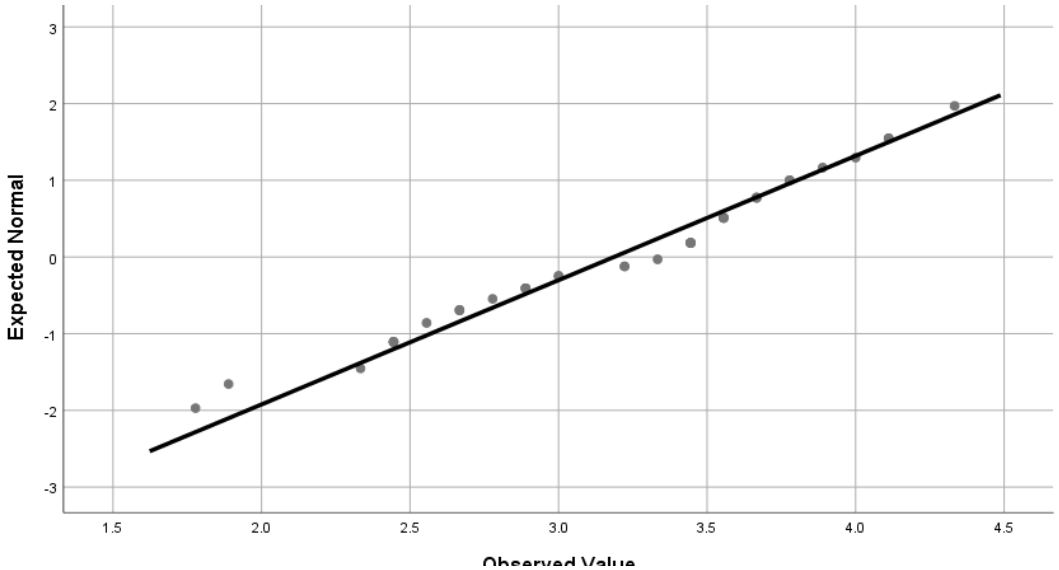
	Shapiro-Wilk		
	Statistic	df	Sig.
Lean-startup adoption	.967	40	.290

Made by the researcher using SPSS

Table 16 above shows that Lean-startup adoption has a sufficient significance (sig = .29> .05) according to the Shapiro-Wilk normality to reject the null hypothesis of not having a normal distribution.

That is supported by the Q-Q plot below in Figure 11. From those two, we deduce that the Lean-startup adoption variable has a normal distribution in addition to being continuous and not having outliers (σ =.64 < 3.29). As a result, the Pearson test of correlation can be used with it, provided that the other variable follows the same conditions.

Figure 11: NormalQ-Q plot of Lean-startup adoption



Made by ourselves using SPSS

4.2. New product innovativeness

The average rate of product innovativeness is around 3.6, and the standard deviation is about 0.83, which means that the majority of results are contained between 2 and 5, which could be explained by the difference in product development strategic orientation mentioned in the literature review, some firms tend to base their objectives on achieving maximum innovativeness while others focus on other strategies. It could also be due to the differences in industries present in the sample.

Table 17: Descriptive Statistics New Product Innovativeness

	N	Range	Minimum	Maximum	Mean	Std. Deviation
New product innovativeness	40	3.67	1.33	5.00	3.57	.83
Valid N (listwise)	40					

Made by ourselves using SPSS

Test of normality

The significance of the score for new product innovativeness is sufficient enough (Sig = .272 > .05) to reject the null hypothesis and consider the distribution to be normal; in addition to that, the standard deviation is less than 3.29, meaning that there are no significant outliers. So, the use of Pearson's measure of correlation is possible.

Table 18: Shapiro-Wilk test of normality, New product innovativeness

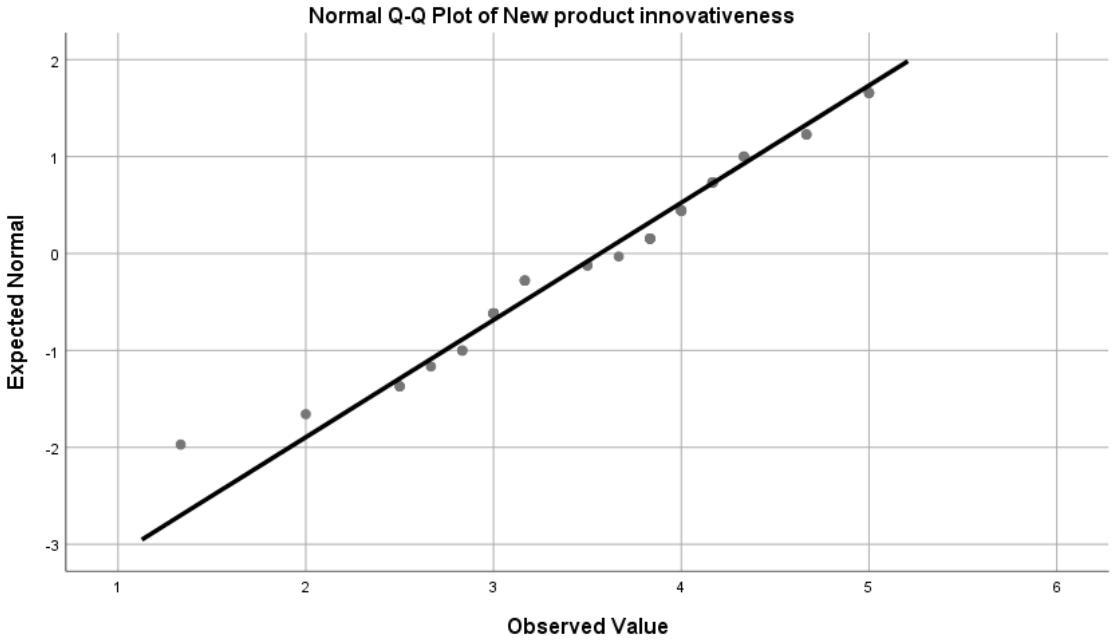
Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
New product innovativeness	.966	40	.272

Made by ourselves using SPSS

The normality is confirmed by the Q-Q plot below, except for one not significant outlier, the rest of the points are more or less close to the normal.

Figure 12: Normal Q-Q plot of New product innovativeness



Made by ourselves using SPSS

4.3. New product performance

Table 19: Descriptive Statistics for the New product performance variable

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
New product performance	40	4.00	1.00	5.00	3.55	.87
Valid N (listwise)	40					

Made by ourselves using SPSS

The average reported performance is about of 3.6 if it is considered with the standard deviation tells us that 95% of values are between 1.8 and 5, which seems logical since no product will be launched for a while if it is considered a complete failure without at least optimizing it if not killing it.

Test of normality

Table 20: Shapiro-Wilk test of normality, New product performance

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
New product performance	.927	40	.013

Made by ourselves using SPSS

The Shapiro – Wilk test's significance is less than .05; therefore, the null hypothesis is confirmed, and the distribution cannot be considered normal. For that reason, Pearson's r cannot be used to estimate correlation, and it will be substituted with Spearman's Rho, which does not assume a normal distribution and is not influenced by outliers.

4.4. Competition intensity:

Table 21: Descriptive Statistics for the Competition intensity variable

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Competition intensity	40	4.00	1.00	5.00	3.12	.94
Valid N (listwise)	40					

Made by ourselves using SPSS

Values are centered around 3.1, and ranging from 1 to 5 with the standard deviation close to 1 push us to believe that the sample contained a balanced representation of companies with high and low competition.

Tests of Normality

Table 22: Shapiro-Wilk test of normality, Competition intensity

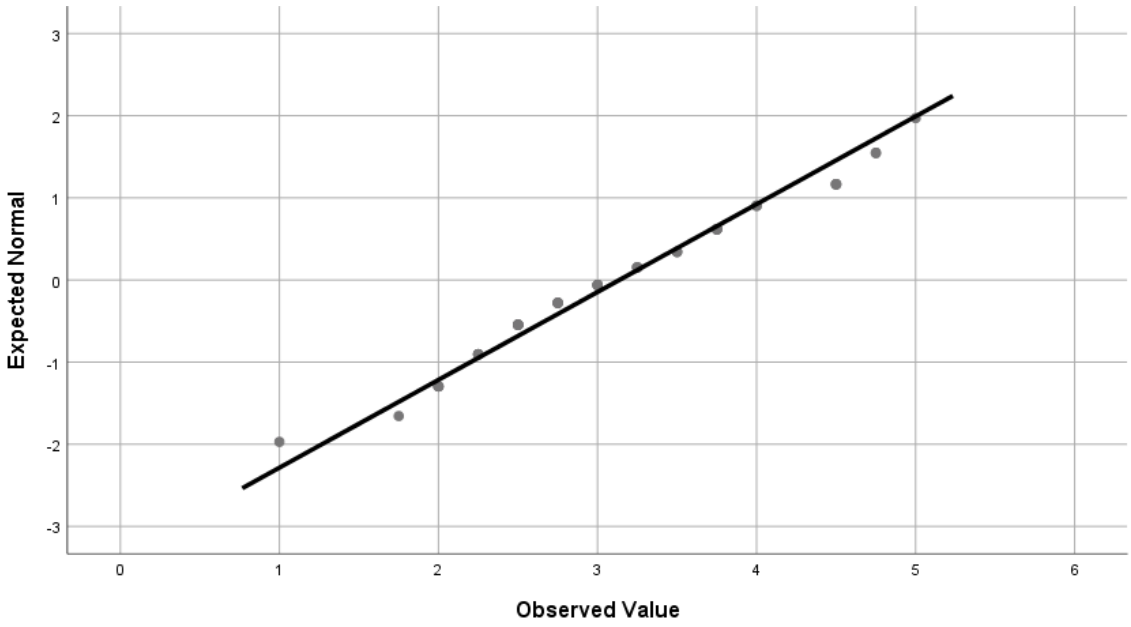
Tests of Normality			
	Shapiro-Wilk		
	Statistic	df	Sig.
Competition intensity	.975	40	.514

Made by ourselves using SPSS

The significance is greater than .05 (Sig = .514), so the distribution can be considered normal. Also, the Q-Q plot shows the points close to the normal, there exists one small outlier, but the standard deviation is a lot less than 3.29 (σ = .92) and can therefore be ignored.

As a result, Pearson's test of correlation can be used with variables respecting the same criteria.

Figure 13: Normal Q-Q plot of competition intensity



Made by ourselves using SPSS

4.5. Innovation culture

The mean is slightly higher than the middle value of 3, which might indicate that a sufficient number of companies in the sample have at least a focus on innovating and installing an innovation environment in the company.

Table 23:Descriptive Statistics for the Innovation culture variable

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Innovation culture	40	3.10	1.70	4.80	3.68	.78
Valid N (listwise)	40					

Made by ourselves using SPSS

Table 24: Shapiro-Wilk test of normality, Innovation culture

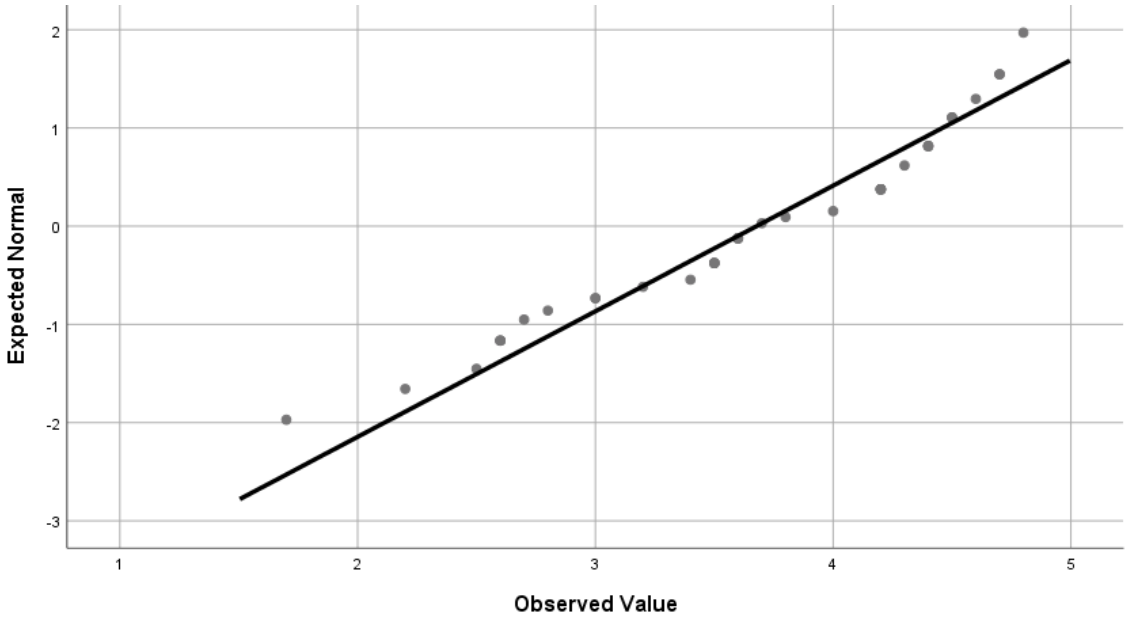
Tests of Normality

Innovation culture	.939	40	.032

Made by ourselves using SPSS

The significance is less than the threshold of .05, so even though the standard deviation (Sig = .78) is less than 3.29. As such, Pearson's test cannot be used with the innovation culture score and Spearman's rho will be used instead; the discrepancies from the normal distribution can be observed in the Q-Q plot below.

Figure 14: Normal Q-Q plot of innovation culture



Made by ourselves using SPSS

4.6. Experience in product management

The values for the items of experience in product management have a large standard deviation, which means that it could be influenced by significant outliers; this is probably due to the questions being open-ended. One outlier was deleted for the number functionalities worked on, others were left as they are.

Table 25: Descriptive Statistics for the Experience items

Descriptive Statistics						
	N	Range	Minimum	Maximum	Mean	Std. Deviation
D1. For how long have you been in the product management field? (years)	40	14	1	15	5.40	3.209
D2. How many different organizations have you undertaken this job in? (Counting your present job)?	40	9	1	10	2.58	1.693
D3. How many different workgroups or teams have you	40	24	1	25	5.43	4.867

performed this job with? (Counting your present job) (Estimate)						
D4. How many features have you worked on in that context? (Estimate)	39	200	0	200	32.08	42.387
D5. How many products have you been involved with as a product manager? (Estimate)	40	59	1	60	12.28	13.407
Valid N (listwise)	39					

Made by ourselves using SPSS

The difference in values for D4 could be explained by the difference in industries, and thus the difference in products; for example, product managers working in software companies will have worked on far more features than consumer or health-oriented companies, which might also explain the relatively large standard deviation of $\sigma = 42.387$.
The large standard deviation in D5 maybe also be attributed to the difference in industries. For the other questions, the standard deviation is significantly less, although higher than 3.29, but that can be attributed to open-ended questions as mentioned before.

The reason for using open-ended questions was the absence of thresholds of experience for different product managers in different industries.

Table 26: Shapiro-Wilk test of normality, Experience items

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
D1. For how long have you been in the product management field? (years)	.908	39	.004
D2. How many different organizations have you undertaken this job in? (Counting your present job)?	.770	39	.000
D3. How many different workgroups or teams have you performed this job with? (Counting your present job) (Estimate)	.724	39	.000
D4. How many features have you worked on in that context? (Estimate)	.714	39	.000
D5. How many products have you been involved with as a product manager? (Estimate)	.663	39	.000

Made by ourselves using SPSS

As the test shows, no item possesses significance that is enough to reject the null hypothesis, that plus the presence of significant outliers justify the use Spearman's rho is used instead of Pearson's correlation coefficient.

5. Verification of hypotheses

Below are the different measurements of correlations relating to our research hypothesis mentioned in chapter 2 and further elaborated on in the following discussion.

5.1. Lean-startup and new product performance

The null hypothesis was analyzed using correlation analysis between the relevant variables; the analysis showed no significant direct correlation (r =.048, sig = .767) between the degree of Lean-startup adoption and the performance of the product.

Table 27: Correlation table, New product performance and Lean-startup adoption

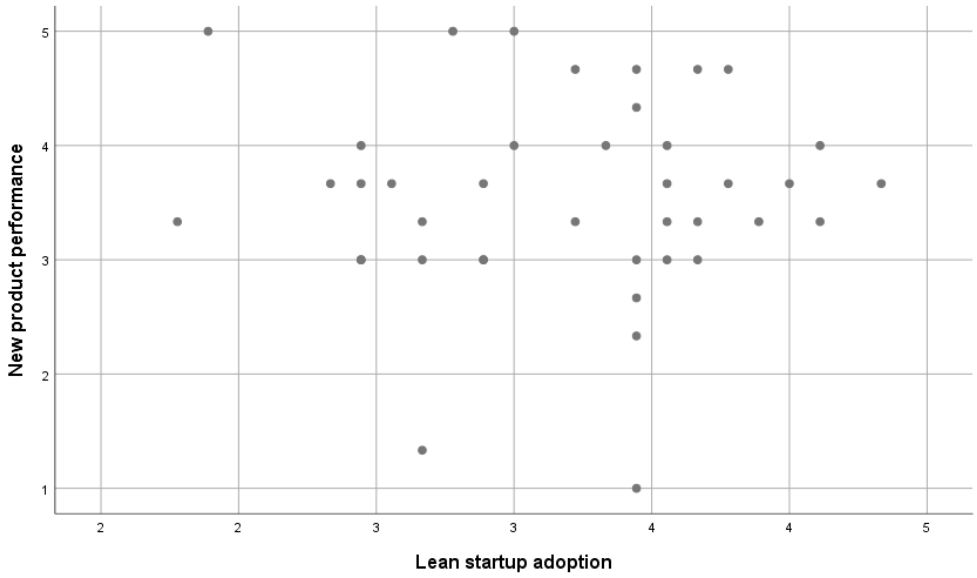
Correlations

			Lean-startup adoption	New product performance
Spearman's rho	Lean-startup adoption	Correlation Coefficient	1.000	.048
		Sig. (2-tailed)	.	.767
		N	40	40
	New product performance	Correlation Coefficient	.048	1.000
		Sig. (2-tailed)	.767	.
		N	40	40

Made by ourselves using SPSS

The scatter plot from figure 15 also shows no sufficiently distinguishable pattern that relates Lean-startup adoption to new product performance.

Figure 15: Scatter diagram, Lean-startup adoption and new product performance



Made by ourselves using SPSS

However, upon further analyzing individual items, we find that statement **A1. "Explicitly stating hypotheses helps to be more conscious of uncertainty"** has a significant positive correlation (Spearman's rho = .396, sig = .012 < .05) with new product performance.

Table 28: Correlation table, New product performance and item A10

Correlations

			New product performance	A10. Explicitly stating hypotheses helps to be more conscious of uncertainty
Spearman's rho	New product performance	Correlation Coefficient	1.000	.396
		Sig. (2-tailed)	.	.012
		N	40	40
	A1. Explicitly stating hypotheses helps to be more conscious of uncertainty	Correlation Coefficient	.396*	1.000
		Sig. (2-tailed)	.012	.
		N	40	40

*. Correlation is significant at the .05 level (2-tailed).

Made by ourselves using SPSS

5.2. Innovation culture and Lean-startup

Regarding Lean-startup adoption and innovation culture, the analysis showed that they do not correlate significantly with each other (Spearman's rho = .87, Sig = .596).

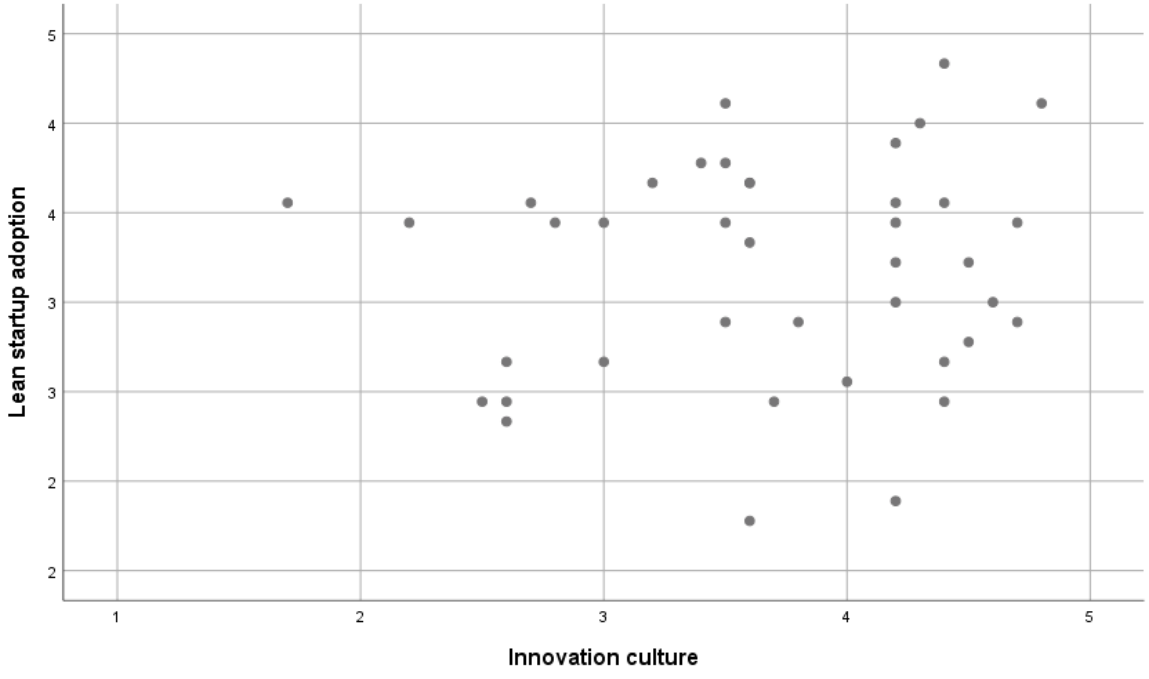
Table 29: Correlation table, Lean-startup adoption, and innovation culture score

Correlations

			Lean startup adoption	Innovation culture
Spearman's rho	Lean startup adoption	Correlation Coefficient	1.000	.087
		Sig. (2-tailed)	.	.596
		N	40	40
	Innovation culture	Correlation Coefficient	.087	1.000
		Sig. (2-tailed)	.596	.
		N	40	40

Made by ourselves using SPSS

Figure 16: Scatter diagram for Lean-startup adoption, innovation culture



Made by ourselves using SPSS

However, we can notice from the scatter diagram in figure 16 that except for two outliers, Lean-startup adoption starts when the company has at least a score of 2.5 in innovation culture, which could mean that Lean-startup practices or some of them at least are a sort of evidence for companies looking to be innovative, meaning the adoption starts when the company is at a certain level and stays constant as supposed to increasing the adoption with increased innovation culture score.

Practices such as being conscious of uncertainty and hypothesis verification before proceeding with actions are not original to Lean-startup because other preceding frameworks had them as well, which pushes for the assumption that they are embedded by any company that progresses a sufficiently enough in innovation culture development.

5.3. Experience and new product success:

A correlation analysis proved that experience in product management and new product success are indeed positively correlated but not using the timescale measurement which although had significant correlation with D3 (r = .474, sig = .002), D2 (r = .398, sig = .011) and D5 (r = .423, sig = .007) it failed to correlate significantly with new product success (r = .122, sig = .455).

Instead of correlating with timescale measurement of experience, new product performance had significant correlation (r= .354, sig = .025) with the number of workgroups that the respondent's product manager worked in, which was found to have an accurate link to the experience construct as mentioned before in the methodology section. While the second item D2 (number of organizations the respondent worked with as a product manager) did not correlate with new product success directly, it had a strong significant correlation with the number of organizations (r = .690, sig < .001).

Table 30: Correlation table (Spearman's Rho) between new product success and experience scales

Correlations

		New product performance	D1. Number of years in product management	D2. Number of organizations worked in as a product manager	D3. A number of workgroups or teams worked with?	D4. Number of features worked on	D5. Number of products worked on
New product performance	Correlation Coefficient	1.000	.122	.304	.354	.039	.059
	Sig. (2-tailed)	.	.455	.057	.025	.815	.717
	N	40	40	40	40	39	40
D1. Number of years in product management	Correlation Coefficient	.122	1.000	.398	.474	.165	.423
	Sig. (2-tailed)	.455	.	.011	.002	.315	.007
	N	40	40	40	40	39	40
D2. Number of organizations worked in as a product manager	Correlation Coefficient	.304	.398	1.000	.690	.059	.139
	Sig. (2-tailed)	.057	.011	.	.000	.721	.393
	N	40	40	40	40	39	40
D3. Number of workgroups or teams worked with?	Correlation Coefficient	.354	.474	.690	1.000	.208	.284
	Sig. (2-tailed)	.025	.002	.000	.	.203	.076
	N	40	40	40	40	39	40
D4. Number of features worked on	Correlation Coefficient	.039	.165	.059	.208	1.000	.107
	Sig. (2-tailed)	.815	.315	.721	.203	.	.516
	N	39	39	39	39	39	39
D5. Number of products worked on	Correlation Coefficient	.059	.423	.139	.284	.107	1.000
	Sig. (2-tailed)	.717	.007	.393	.076	.516	.
	N	40	40	40	40	39	40

Made by the researcher using SPSS

5.4. Competitive intensity and Lean-startup

The analysis showed no significant correlation between the intensity of competition and Lean-startup adoption. This could be due to the industry differences that, in turn, provide differences in orientations but could also be due to the level of uncertainty that those companies live in.

Table 31: Correlation table, Competition intensity, and Lean-startup adoption

Correlations

		Competition landscape	LS adoption corrected
Competition intensity	Pearson Correlation	1	-.229
	Sig. (2-tailed)		.155
	N	40	40
LS adoption	Pearson Correlation	-.229	1
	Sig. (2-tailed)	.155	
	N	40	40

Made by ourselves using SPSS

5.5. Lean-startup and new product innovativeness

Lean-startup adoption apparently is not inversely correlated with new product innovativeness due to low and insignificant correlation (r = .077, Sig = .652). However, the result seems more logical this way because if we consider the two extreme cases, one being a product that does not require much innovation such as mass consumer products, and the other extreme case of next-generation disruptions, it is hard to imagine the existence of a simple reverse linear relationship between Lean-startup adoption and product innovativeness.

Table 32: Correlation table, New product innovativeness, and Lean-startup adoption

Correlations

		Lean-startup adoption	New product innovativeness
Lean-startup adoption	Pearson Correlation	1	.079

		Sig. (2-tailed)		.627
		N	40	40
New innovativeness	product	Pearson Correlation	.079	1
		Sig. (2-tailed)	.627	
		N	40	40

Made by ourselves using SPSS

6. Additional findings

6.1. The scope of use for the different frameworks and their reported familiarity

We can observe in the map of figure 17 the following:

For Lean-startup: the use is strongly focused around stages of product and concept development and idea screening and optimization to a lower degree. It is weak during commercialization and rollout, ideation, and optimization. This is very useful as it shows that Lean-startup strength is in the pre-commercialization activities and after the ideation phase.

For design thinking: the use has a strong inclination towards the ideation phase; apparently, product managers also like using it for pre-commercialization, screening, and optimization

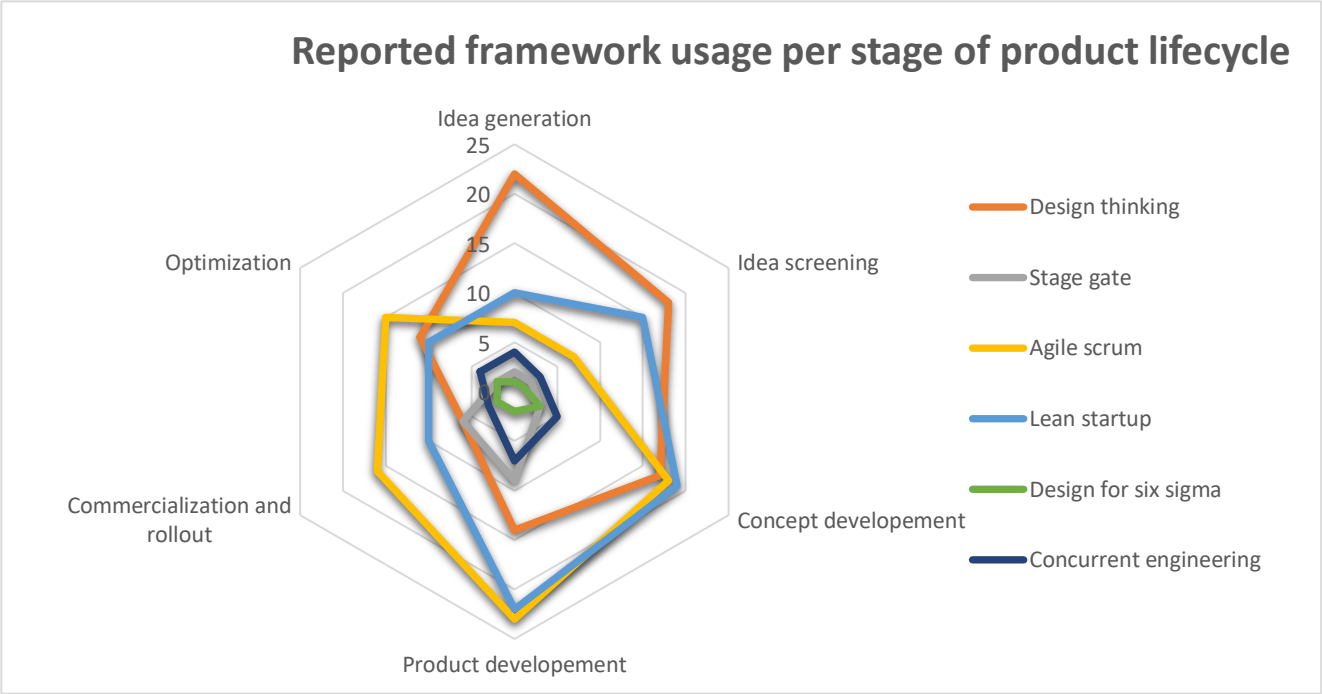
For Agile-scrum: we notice a strong incline to the actual deployment activities of product development, commercialization, and optimization more so than any other framework that also supports the literature review, as Agile-scrum starts development as soon as the product owner determines user stories. Its weak use in pre-development activities shows the necessity of having other frameworks in place.

Like Agile, the use of **stage-gate** seems to be concentrated on the actual delivery of the product, i.e., development and the commercialization and rollout with weaker strength.

Concurrent engineering usage also focuses on product delivery and concept development; however, the lack of reported use noticed in it and in **design for six sigma** makes it harder to affirm the inclination strength.

The use of **design for six sigma** shows a small inclination towards optimization, but as mentioned before, the strength cannot be affirmed due to the lack of reported use.

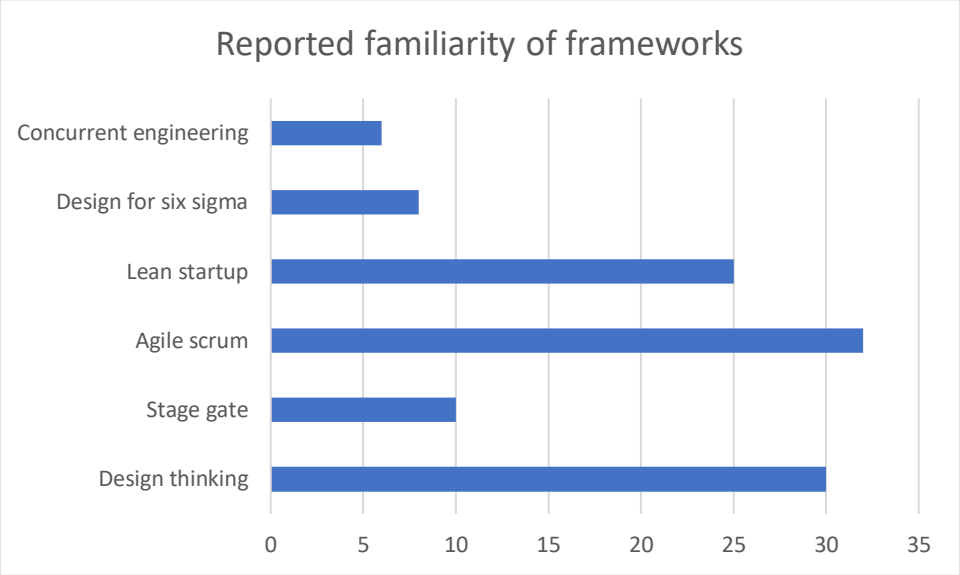
Figure 17: Reported framework usage per stage of the product lifecycle



Made by ourselves using Excel

One other thing that might be worth noticing is that the three strongest reported frameworks are in order of strength: Agile-scrum, Design Thinking, Lean-startup; as we can observe in figure 18, all three have the notion of iterations as supposed to Stage-gate. While design for six sigma and concurrent engineering are described as iterative in nature, apparently they are less known and/or less used among product managers than the previously mentioned three.

Figure 18: Reported familiarity of frameworks by respondents



Made by ourselves using SPSS

6.2. Innovation culture and new product innovativeness

Upon analysis of different variable relationships, we find a significant correlation between having an innovation culture and the product's degree of innovativeness. This insight provides us with the motivation to install an innovation culture in the aspiration of it reflecting on the product.

Table 33: Correlation table, Innovation culture, and new product innovativeness

Correlations

			Innovation culture	New product innovativeness
Spearman's rho	Innovation culture	Correlation Coefficient	1.000	.402*
		Sig. (2-tailed)	.	.010
		N	40	40
	New product innovativeness	Correlation Coefficient	.402*	1.000
		Sig. (2-tailed)	.010	.
		N	40	40

*. Correlation is significant at the 0.05 level (2-tailed).

Made by ourselves using SPSS

Table 34: ANOVA table for innovation culture and new product innovativeness

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.006	1	5.006	8.787	.005[b]
	Residual	21.650	38	.570		
	Total	26.656	39			

a. Dependent Variable: New product innovativeness

b. Predictors: (Constant), Innovation culture

Made by ourselves using SPSS

Next, we run a linear regression analysis to prove causality. Table 34 shows that the mode is indeed significant ($F(1,38) = 8.787$, p (sig) = .005 < 0.05), which rejects the null hypothesis (sampling error) which allows us to continue with our regression analysis.

With further analysis, we find that the innovation culture can explain up to 16.6 % of new product innovativeness variation; one thing to consider is the various industries present in the sample, which could be the reason for the relatively small impact. However, this does show a general benefit that can be acquired by installing the innovation culture.

Table 35: Linear regression model summary, Innovation culture new product innovativeness

Model Summary

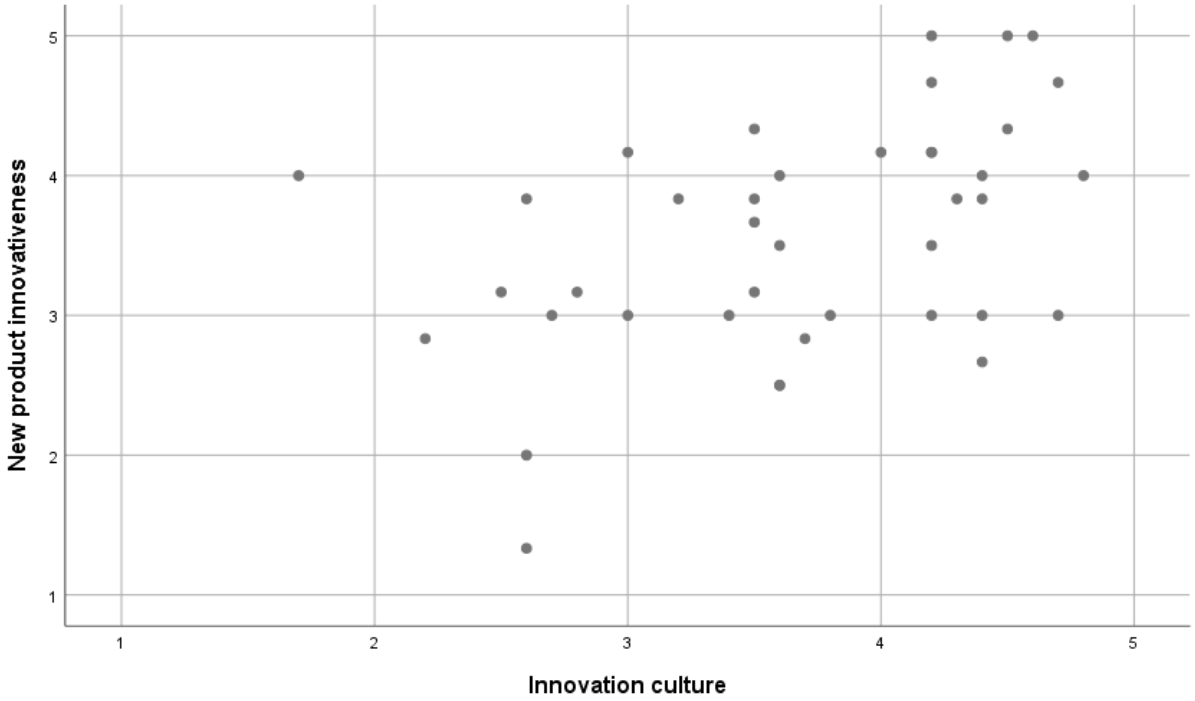
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.413[a]	.188	.166	.754801251982225

a. Predictors: (Constant), New product innovativeness

Made by ourselves using SPSS

We can notice the general tendency more clearly in the scatter plot in Figure 19 below. As the innovation culture score increases, more points are found in the upper section of new product innovativeness.

Figure 19: Scatter plot, new product innovativeness, and innovation culture



Made by ourselves using SPSS

6.3. New product innovativeness and new product performance

The analysis also showed a significant positive correlation between new product performance and innovativeness (Spearman's rho = .397, sig = .011); this could be perhaps explained by a general tendency for people to choose solutions that are more innovative, which not only provides motivation to invest in R&D but also from previous results to install a culture that supports innovation and possibly evaluating it periodically and compare it to the overall performance, the fact that this tendency is discovered despite the difference in industries could be a sign of further benefits of adopting innovation as a goal and mindset.

Table 36: Correlation table, New product innovativeness, and New product performance

Correlations

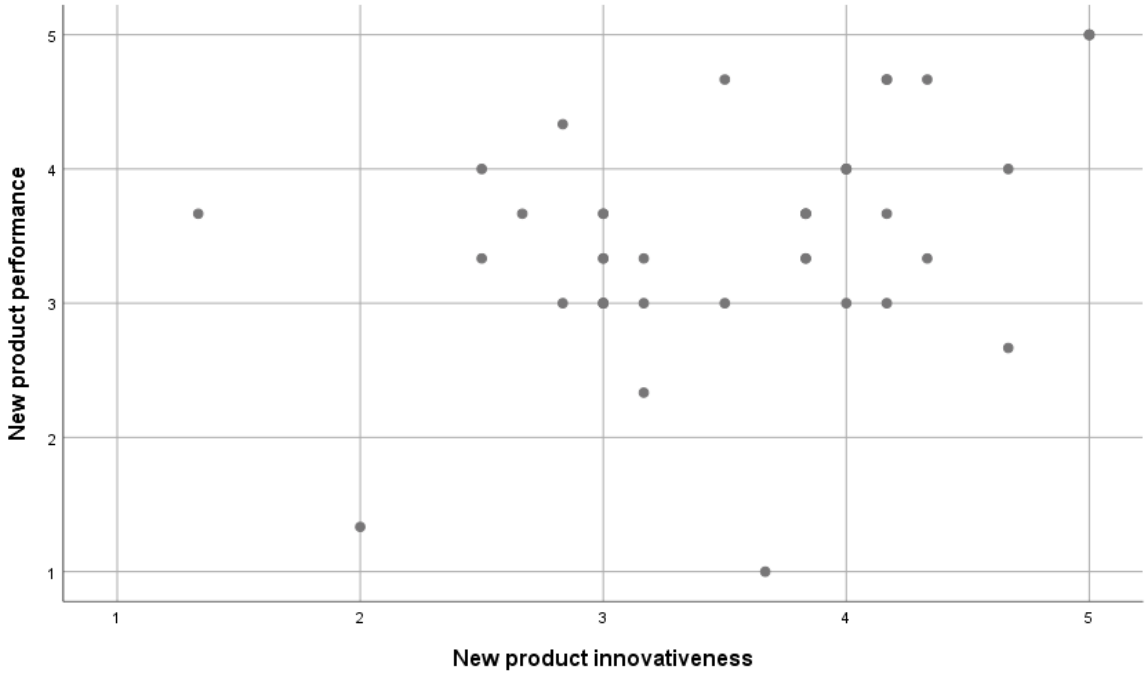
			New product performance	New product innovativeness
Spearman's rho	New product performance	Correlation Coefficient	1.000	.397
		Sig. (2-tailed)	.	.011

		N	40	40
	New product innovativeness	Correlation Coefficient	.397	1.000
		Sig. (2-tailed)	.011	.
		N	40	40

*. Correlation is significant at the .05 level (2-tailed).

Made by ourselves using SPSS

Figure 20: Scatter plot, New product performance, and new product innovativeness



Made by ourselves using SPSS

7. Discussion:

To answer our research question, hypotheses were formed in the methodology section and tested in the previous subsection titled “hypothesis verification.” relevant results discussion is presented below

Lean-startup and new product performance: No significant correlation was found between the two constructs, which confirm our null hypothesis H0 and support prior research by Ramm (2015).

However, the significant positive correlation between item A10 and new product performance score might indicate that being aware of the product's assumptions help mitigate risk, thus increasing the chance for product success. It also poses the possibility that while the overall adoption of Lean-startup is not directly impacting performance, using some of its components combined with other methodologies could lead to better results.

Innovation culture and Lean-startup: No significant correlation was found between the innovation culture score and lean-startup adoption, thus refuting H1.

That does not necessarily mean, however, that Lean-startup has no link to innovation culture. As mentioned before, the adoption of the framework's components might happen at a stage of innovation culture nurturing but not develop further, an insight provided by the scatter diagram in figure 16. In addition to that, companies with a high level of innovation culture might combine different frameworks instead of focusing on just one.

Experience and new product success: The assessment of the relationship between new product performance and scales for experience yielded exciting results. As traditional timescale measurement did not correlate with performance, which supports research by Shackleton (2016) and that timescale measurement of experience is a poor indicator of skill or the candidate's experiences during that time.

Another insight that supports Shackleton (2016) is that new product performance had a significant correlation ($r = .354$, $sig = .025$) with the number of workgroups that the respondent's product manager worked in.

As such, H2 is supported if we consider the measurement of experience conducted using the previous scale of the number of workgroups.

Competitive intensity and Lean-startup: Competition intensity score did not correlate with Lean-startup adoption, thus refuting H3, this could mean that competition intensity is a function of multiple variables and conditions that the research did not control for sufficiently. One example of this could be that dealing with competition differs based on the specific market stakes and, in turn, the company's product development strategic orientation. As mentioned in the theoretical framework, some companies will focus on innovation while others on aspects such as low cost.

Lean-startup and new product innovativeness: similar to the previous 2 points, Lean-startup adoption did not correlate significantly with new product innovativeness, although this refutes H4 for assuming a negative relationship, it does not necessarily mean the absence of a connection since we used Pearson's correlation coefficient this could mean that there is

not a linear relationship between the two constructs and following the previous example of the two extreme cases (Radical innovation ex: Cancer treatment, low innovation ex: consumer necessities), it might be more interesting to study the impact on product's uncertainty instead of product innovativeness as that is supported by prior research (Patz, 2013) as mentioned in the literature review. Doing so will make the extreme cases of radical innovation and conventional products both have low relative uncertainty. For example, cancer patients try every experimental solution that shows some promise, and on the other end, people will most likely continue to buy their necessities.

Scope of use for different frameworks: Results show a trend towards using iterations as supposed to linear processes, which is relevant to the argument mentioned in the literature review between the use of linear models such as conventional stage-gate and the use of ones such as Lean-startup.

Results also show many elements supporting the description of each method in the conceptual framework as Design thinking being more inclined towards ideation and Agile towards actual product development.

Both Design Thinking and Lean-startup find their use concentrated on phases before commercialization with a difference between them is that the latter does not have a strong emphasis on the ideation phase.

Conclusion

Iterative processes came before Lean-startup. However, the framework heavily influenced the startup and innovation dialect. It brought about the notion of hypothesis-driven experimentation in a more straightforward manner accessible by those not particularly experts in the field. While many call it necessary common knowledge about innovation in our days, exact scientific results about its precise impact on new product development are not exhaustive.

The research aimed to find out general tendencies about the impact of Lean-startup on new product development. For that purpose, a scale correction for Lean-startup using content validity index was undertaken. Proceeded by operationalizing other constructs directly linked to new product development such as performance and innovativeness, and indirectly linked such as innovation culture, measures of experience in product management, and competition intensity. Following that, a quantitative study was conducted through a survey.

Results show that Lean-startup adoption does not directly impact performance. However, the link found between item 10 and performance pushes us to believe that while components of the framework can offer benefit, it might be counterproductive to go to the extremes of adopting just one framework instead of combining different frameworks.
Similar to the previous result, Lean-startup adoption was not found to impact new product innovativeness significantly, and it was not strongly related to competition intensity either. This result might show that more control variables are needed to test the company strategy and the industry's impact.

So, to answer the research question was formed as the *following* ***"What is the impact of Lean-startup on new product development?"*** these findings suggest that no direct impact was observed on new product performance or innovativeness similar to previous research. However, it might be more useful to assess the benefit from another perspective, such as risk mitigation and management, to investigate further the link between hypothesis statement and new product performance.

A link was found between company innovation culture and new product innovativeness, showing that innovation culture explains up to 16.6% of the variation for new product innovativeness.

While answering in our view, the research objectives, this work is not free of limitations ones shared with Ramm (2015), is the relatively small size of respondents. Although we contacted, as mentioned before, 800 product managers, the final sample size was 40. While generally, a size of 30 is considered acceptable as a minimum for statistical significance (Hogg et al., 2019), we still have worries about results' generalizability because of company-related factors.
Another aspect worth considering is the relative freedom that product managers had concerning product choice. While results confirmed earlier research, whether it is the relationship with the experience metric or with Lean-startup adoption, it is still a possibility that some product managers will be prone to confirmation bias and choose products they best performed at, something that is allowed by the subjective measure of performance.

However, those limitations provide implications for future research as the different variables used to capture the environmental impact on the primary research question (competition intensity, innovation culture, experience, company size, age, and industry) can be used as control variables as to provide more efficient generalizability of results. An example would be the research on incubators' efficiency by comparing the frameworks used by their startups.

Despite having a different focus than Ramm (2015) as his criteria were not the product's performance but the company's success, it can be said the results are very similar. As such, we propose that future research assesses the impact of Lean-startup on other perspectives, such as the proposed risk management and reducing uncertainty. Arguments for this proposition being: the repetitive mentioning of uncertainty in relevant literature about Lean-startup, the popularity of the framework, and the relationship found before.

The work also contains implications for companies wishing to develop and recruit product managers to not heavily depend on years of experience to measure product management skills. Instead, more weight of consideration should be on the two scales of the number of workgroups and organizations as they proved more linked to product performance. Companies wishing to develop their product managers' skillset should consider putting them intentionally to work with different teams to let them get accustomed to many situations and hopefully increase their ROI.
Other important managerial implications are:

The relationship of product innovativeness and performance, it was found that the two are significantly correlated. In addition to that, company innovation culture was found to impact innovativeness, which supports nurturing innovation in the company to help increase performance.

The research also provides managers with preferred methods for the different stages of the product development lifecycle ex: Design thinking perhaps for ideation, Lean-startup post ideation, and pre-development followed by an Agile inspired variation to physically build the product. Interestingly enough, that happens to be the combination recommended by Blank (2013).

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Appendixes

8. Appendix 1: Variables

Variable	Source of questions adapted and modified	Corresponding items and Variables
Lean-startup adoption	(Ramm, 2015), Corrected	Average [A4: A12]
Company Innovation supporting culture	(Denison & Janovics, 2006)	Average [B1:B10]
Company competition intensity	(Jaworski Kohli,1993)	Average [sum (C2: C5)]
Experience in product management and development	(Shackleton,2016)	D1 D2 D3 D4 D5
Product innovativeness	(Moorman,1995)	Average [E4: E9]
New product success	(Song & Parry,1997)	Average [E1: E3]

9. Appendix 2: Questionnaire

Hello, my name is Cheriet Seddik (a master student in strategic management and information systems). I am conducting my graduation research on product success under the supervision of professor Abdelmalek Mezhouda in the department of organizational management and entrepreneurship in the ENSM (National Superior School of management) Kolea, Algeria.

To participate in the research and receive a summary of results, later on, the completion of the following survey is necessary. It should take about 20-30 min of your appreciated time.

Individual Participants will not be disclosed nor identifiable by other than who has access to the form for data analysis and should be destroyed after a period of time.

Informed consent:

This is just to make sure you agree to participate voluntarily and understand that :

- You agree to participate in this survey.
- You may withdraw from participating at any time, and you don't have to specify any reason.
- We will keep your answers and your identity as confidential as possible with the consideration of google forms privacy policy.
- Once the project is finished and decisions for further research use is taken, all data you have contributed will be deleted.

[I accept], [I don't accept]

Instructions:

In the following sections, you will be presented with statements and questions regarding product management and development, your company, and non-identifiable products. We would like to know if you view on a statement and your answers the questions

When answering, try to consider what makes sense to you according to your experience. If a statement doesn't apply to you, answer what you thing would generally apply.

For specific questions about the company or products, please consider experiences in the last 5 years.

Feel free to leave a comment at the end of the survey if you would like to elaborate on any of you answers.

To help us reach a sufficient number of answers, consider mentioning two emails of individuals you think will have useful input.

As a thank you for participating, we would like to offer you the chance to receive a summary of the results of the survey once we've completed the project. You will have the option to sign up for this in the end.

Filtering question:

Does your responsibilities include:

- ☐ Understand customer experience
- ☐ Develop vision
- ☐ Prioritize processes and activities
- ☐ Develop product pricing and positioning strategies
- ☐ Build and follow a roadmap
- ☐ Arrange product testing groups
- ☐ Drive product launch
- ☐ Participate in the promotion plan development
- ☐ Build and maintain product awareness on all levels among product teams

<u>Company and individual-related information:</u>

Company Name:…….

How long has it been since your current company was formally founded?

- o Less than a year
- o 1-5 years
- o 6-10 years
- o 11-15 years
- o More than 15 years

What is the size of your current company?

- o 1- 49 employees
- o 50- 249 employees
- o More than 250 employees

In which of these industries is your company active? (dropdown)

What is your official title in your current company?

……

In which country do you work?

……

How old are you?

- Below 25
- 25-35
- 36-45
- 45-50
- More than 50

What is your gender?

- Male
- Female

What is your highest completed level of education?

- Highschool
- Bachelar
- Master
- PhD

What is your field of education?

- IT
- Entrepreneurship
- Business
- Economics
- Marketing
- Natural science/ Engineering
- Social science

Section A: Product management statements:

The statements below are about product management. How strongly do you agree/disagree with them? Following them are two questions related to your experience.

A1. “Getting feedback from customers should have higher priority than working on the product.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A2. “A business plan always needs to be changed once you start putting it into action.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A3. “It is more valuable to do experiments than to keep your initial customers at all costs.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A4. “When launching a new product, you should make sure the product is as good as possible before you start selling it” (reversed scale)

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A5. “Good entrepreneurs are visionaries, and it’s important to be able to stick with the plan even if the market hasn’t responded yet” (reversed scale)

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A6. “Working toward the original vision is more important than adapting to feedback from potential customers” (reversed scale)

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A7. “Trying to sell the product is more important than finalizing the business plan.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A8. “The best way to get credible feedback is to try and sell your product.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A9. “Detailed long-term planning is more important than conducting experiments early on in the product project” (reversed scale)

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A1. “Explicitly stating hypotheses helps to be more conscious of uncertainty.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

A11. Mention 3 key metrics you continually monitor to judge performance in your latest product project.

……

A12. Which of these, if any, are techniques you used:

□ Cohort analysis

□ Split testing A/B testing

□ Low/high fidelity prototypes

□ Iterative development

□ 5 Why (or root cause) analysis

□ Customer interviews

Section B: Company environment

Please respond according to the company you were employed/founded during the period until January 2020

B1. “The way things are done is very flexible and easy to change.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B2. “We respond well to competitors and other changes in the business environment.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B3. “New and improved ways to do work are continually adopted.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B4. “Attempts to create change usually meet with resistance.” (Reversed Scale)

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B5. “Different parts of the organization often cooperate to create change.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B6. “We view failure as an opportunity for learning and improvement.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B7. “Innovation and risk-taking are encouraged and rewarded.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B8. “Lots of things "fall between the cracks." (Reversed Scale)

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B9. “Learning is an important objective in our day-to-day work.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

B1. “We make certain that the "right-hand knows what the left hand is doing."

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

Section C: Competition state

C1. “Competition in our industry is cutthroat.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

C2. “There are many “promotion wars” in our industry.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

C3. “Anything that one competitor can offer, others can match readily.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

C4. “Price competition is a hallmark of our industry.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

C5. “One hears of a new competitive move almost every day.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

C6. “Our competitors are relatively weak.”

○ Strongly disagree ○ Disagree ○ Neither agree nor disagree ○ agree ○ Strongly Agree

Section D: Work experience

D1. How many years have you worked on product management responsibilities in your career?

……

D2. How many different organizations have you undertaken this job in? (Counting your present job)?

……

D3. How many different workgroups or teams have you performed this job with? (Counting your present job) (Estimate)

.....

D4. How many features have you worked on in that context? (Estimate)

……..

D5. How many products have you been involved with as a product manager? (Estimate)……..

D6. Which of these models are familiar to you?

□ Design thinking

□ Stage gate

□ Agile-scrum

□ Lean-startup

□ Design for six sigma

□ Concurrent engineering

D7. Where, if any, did you use some or all of these models in: Idea generation, Research, Product development, Process development, Launch, Optimization? If you didn't use one or some techniques, leave its line blank //Matrix

Section E: Performance of a new product

For these questions consider a new product you worked on in the last 5 years.

E1. How successful was this new product from an overall profitability standpoint?

- A great financial failure.
- A financial failure
- We brock-even
- A financial success
- A great financial success

E2. Relative to your firm's other new products, how successful was this new product in terms of revenues?

- Far less than our other new products
- Less than our other new products
- Same as our other new products
- Greater than our other new products
- Far exceeded our other new products

E3. Relative to your firm's objectives, how successful was this new product in terms of profits?

- Far less than our objectives
- Less than our objectives
- Achieved our objectives
- Exceeded our objectives
- Far exceeded our objectives

E4. The new product was:

- Very ordinary for our industry
- Ordinary for our industry

- Somewhat novel for our industry
- Novel for our industry
- Very novel for our industry

E5. The new product was:

- Not challenging to existing ideas in our industry
- A little bit challenging to existing ideas in our industry
- Neutral
- Somewhat challenging existing ideas in our industry
- Challenging to existing ideas in our industry

E6. The new product:

- Not offering new ideas to our industry
- Probably did not offer new ideas to our industry
- Neutral
- Probably offered new ideas to our industry
- Definitely offering new ideas to our industry

E7. The new product was:

- Not creative
- Not totally creative
- Neutral
- Somewhat creative
- Creative

E8. The new product was:

- Uninteresting
- Not totally interesting
- Neutral
- Somewhat interesting
- Interesting

E9. The new product:

- Was not capable of generating ideas for other products
- Was able to some extent of generating some ideas for new products
- Neutral

- Was able to some extent of generating ideas for new products
- Was capable of generating ideas for other product