

## MASTER

### How start-ups can build a supply chain to support their business strategy

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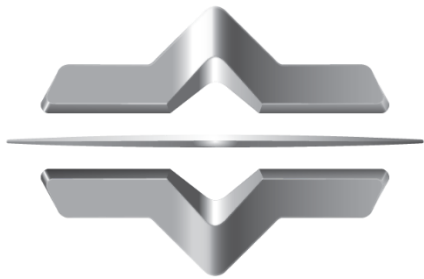
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# Master Thesis

*How start-ups can build a supply chain to support their business strategy*

Eindhoven University of Technology



# PAL-V

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# Master Thesis

## *How start-ups can build a supply chain to support their business strategy*

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## Abstract

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Start-ups play a significant role in economic growth by creating jobs, spurring innovation, and challenging the status quo. These start-up must build a supply base from the ground up, unlike established firms. This is a challenging assignment for which no guidelines exist. This study investigates how a start-up can build a supply chain to support its future business strategy. The study uses a case study of Dutch start-up PAL-V, a manufacturer of flying cars. PAL-V needs a supply chain because its vehicles will enter the market in 2020. In order to build that supply chain, the study has identified four constructs that should be considered by the firm: the make-or-buy decision, supplier involvement, supplier selection, and relationship management. This study uses an interactive design approach to develop practical applications for these constructs, resulting in six elements. The elements are implemented and evaluated within the organization. Based on these findings, the study suggests a new research framework for start-ups and proposes a purchasing and supply chain strategy for PAL-V.

# Management Summary

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## Introduction

The participation of suppliers is vital for the existence of new ventures. Suppliers not only provide resources but could also provide knowledge and funding. PAL-V, a Dutch start-up and a pioneer in flying cars, will launch its first commercial vehicle in 2020. The firm produced one test vehicle, which indicated that the cost price should be reduced. However, the firm has no strategy or suppliers to accomplish this objective. In addition, the firm is entering an established market with larger enterprises and is challenged by a time restriction. Based upon these challenges, the following problem statement is formulated:

***PAL-V, a highly innovative start-up, is missing a supply chain to support its future business strategy.***

In order to find a solution to the above stated problem statement, a more generally formulated research question is defined:

***How can a highly innovative start-up build a future-proof supply chain to support its business strategy?***

The objective of the study is twofold. Firstly, the study aims to develop a solution for PAL-V's missing supply chain. Secondly, the study wishes to contribute to the literature on purchasing and supply chain management (PSM) and new ventures. The study therefore applies a reflective design knowledge-generating process. Our research starts with a systematic literature review to define a preliminary research model. This model indicated that the business context must be understood before a solution could be designed. Hence, the second step of the research is an analysis of PAL-V's business context. Next, a focus group with leading supply chain experts was conducted to form implications for the solution design. Interactive meetings further deployed the solution design within the organization. Finally, a general theoretical design proposition was proposed in the last phase of the process.

## Theoretical Findings

The literature review initially revealed three key elements of supply chain management to support a start-up business strategy. The first element is the make-or-buy decision. The literature review finds that transaction cost economics and the resources-based view as underlying theories could support the make-or-buy decision. The second element is supplier involvement because it is critical for outsourced components and activities. Literature argues that suppliers should be involved timely in new product development (NPD) as this could increase performance. The procurement department should be qualified to support NPD. In doing so procurement specialist should be capable to manage human interaction. The third element is supplier selection since supplier involvement can only succeed if the right partner is chosen. The literature has argued that while strategic objectives may influence selection criteria, considering cost factors alone seems to be too short-sighted. Instead, start-ups should guide supplier selection with a balanced set of quality, delivery, and cultural criteria. A fourth construct, relationship management, was added after the literature review revealed its relevance. Relationships require trust between firm and vendors, otherwise supplier involvement cannot succeed. Lastly, these four elements are affected by the specific business context of the new ventures. Based upon the forgoing, a preliminary research framework was constructed.

## Analyzing the Business Context to Facilitate the Solution Design

The business context in which PAL-V operates was analyzed as a preliminary step to designing a solution to the problem. The analysis was divided into three parts: mapping the business strategy and sales forecast; conducting a spend analysis; and organizing a focus group discussion with leading supply chain experts. PAL-V proves to be a technically driven company with a strong preference to keep activities in-house. The firm does not, however, consider the steep ramp-up after the second year of production. Hence, PAL-V should consider finding partners to increase the order capacity. The spend analysis provided new insight into the cost price structure of the vehicle. Moreover, it became apparent that a significant share of the total components is unknown for the procurement department; non-recurring expenses could significantly influence cost and lead time; and items are predominantly sourced in Western Europe whereas the first steps towards global sourcing have been made. The supply chain experts argued when dealing with suppliers, PAL-V should exploit its marketing appeal and growth potential to increase incentives of suppliers to be involved. In addition, the experts stated that while global sourcing could provide interesting opportunities, it should be carefully considered at this stage. If products are critical, then supplier's geographical proximity should be preferred because it facilitates communication.

## Solution Design and Implementation

Following our research framework, our solution design covers six elements. Firstly, PAL-V should for its critical components conduct a thorough make-or-buy analysis as this analysis for four of PAL-V's components lead to major changes. Just to illustrate: instead of making the weld assemblies and rotor blades, it was decided to outsource these in the future. Secondly, PAL-V should pursue a predetermined commodity strategy for each component group to guide sourcing decision making both at the supplier and component level. Thirdly, a concise planning schedule is needed to facilitate the complex and frequent interaction and communication between engineering and procurement department. Such schedule is mandatory to keep the department informed about the development and sourcing status at module and component level. Fourthly, the incumbent supplier selection model was revised to better fit with PAL-V's business strategy. Selection of vendors proceeds through four steps: An initial screening, an extensive qualification, a detailed cost trade-off, and score evaluation and supplier selection. Fifthly, a supplier program was conceived to engage PAL-V intensively with its key suppliers. This program will form the base of any activities pursuing to increase relationships. Finally, a purchasing and supply chain strategy was designed to ensure cohesion among the previous five elements. The strategy led to a revision of the research framework after the design was finalized.

## Discussion and Conclusion

A research framework was proposed for start-ups that are seeking to build a supply chain. The framework, depicted in *Figure 1*, consists of defining and understanding the business context in which new ventures operate, a top-level structure (business and PSM strategy), and four constructs: make-or-buy, supplier involvement, supplier selection, and relationship management. A start-up should first understand its business context before composing a PSM strategy. The start-up should then carefully resolve the make-or-buy decision. This decision should be based recognizing IP protection and capitalizing on the core competences of the firm. For outsourced components, it is important to involve suppliers timely in NPD which in essence is about building trust between supplier and buyer. Therefore, strategic, operational, and collaborative processes need to be in place.

In addition, a start-up should exploit its marketing appeal and growth potential to increase incentives for suppliers to become involved. It should built relationships with local suppliers as this will facilitate communication. To put it differently, global sourcing for critical items in particular, should be carefully considered. However, involvement of suppliers can only succeed if the right supplier is chosen. Hence, a start-up should use a balanced set of quality, delivery, and cultural criteria to guide supplier selection. Finally, the research investigates relationship management, a construct that is relevant to all the topics mentioned above. Start-ups should organizational wide be aware of the importance of such relationships. What matters is how a firm treats its partners, which resolves from the company's culture. It takes time to build a relationship, hence, new ventures should not damage trust and communicate with their suppliers openly, honestly, and frequently.

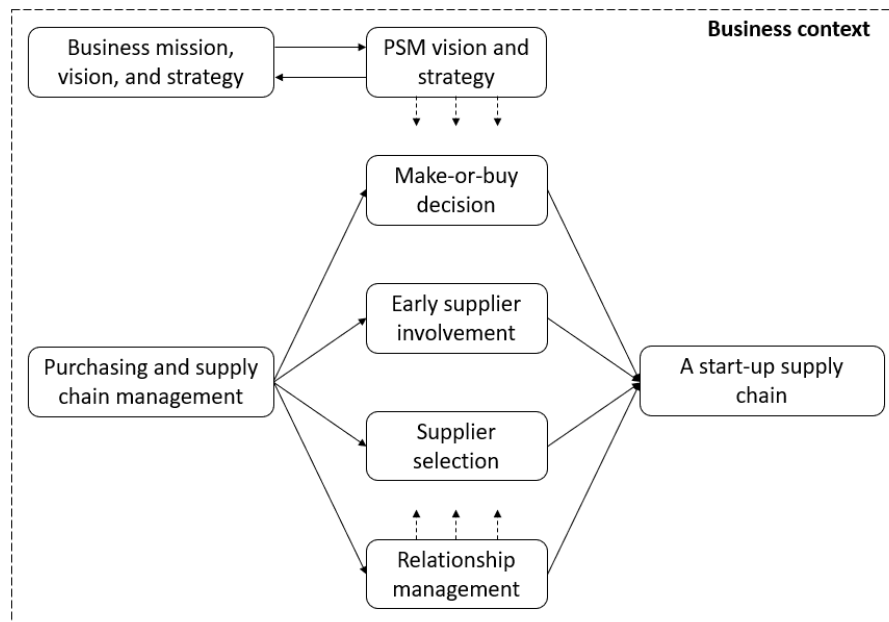


Figure 1: Research framework



## Preface

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As completion of the master Innovation Management at the Eindhoven University of Technology, I executed a graduation project at PAL-V Operations BV. This project taught me a great deal about managing and resolving complex business problems. Herein, it is evident to me that I could not have succeeded without help. Therefore, I would like to take the opportunity to express my gratitude to all people who have supported, coached, and inspired me during the past 6 months.

First, I would like to thank my supervisors at the Eindhoven University of Technology. I would particularly like to thank, my first supervisor, Prof. Dr. Arjan van Weele, who supervised me during the master thesis. You have been an inspiration and inexhaustible source of knowledge. Your feedback and guidance helped me bring this thesis to a new level and spiked my enthusiasm for supply chain management. I could not have successfully completed it without your help. Additionally, I want to thank my second supervisor, Dr. Sharon Dolmans. Her valuable feedback about structure and methodology helped me to make this report cohesive.

Second, I would like to thank PAL-V for providing me with the opportunity to define and conduct my own research project. Special thanks are due to my supervisor Jeroen van de Braak for listening to and supporting me during this period. Our interactive meetings and your constructive feedback gave me new insights to tackle problems along the way. You granted me freedom while also helping me to navigate in the right direction. I want to express my gratitude to Wouter van Dijk as well. Your practical knowledge on the component and supplier levels provided me with greater depth in the research solutions. Furthermore, I want to acknowledge Bartjan Rietdijk with whom I have had many conversations that have led me to view many aspects from a different perspective. I further thank you for your trust in me and your positive mindset. I also would like to acknowledge my many fine colleagues at PAL-V. You not only contributed with valuable input on the research but also made me feel welcome at your organization.

Third, I would like to thank my family and friends, who made it possible for me to complete my master's thesis. Moreover, you patiently listened to my endless thoughts and ideas, which we have discussed in depth. Two people deserve special mentions for supporting me my thesis. First, special thanks to my father Ad Weterings, who provided me with useful practical advices throughout the project. Second, I would like to thank my roommate Kasper Bossink, who gave me his honest opinion and with whom I could constantly share my thoughts. I would like to express my gratitude to the chief procurement officers who participated in the focal group. Your recommendations were highly appreciated.

Reinier Weterings

Eindhoven, February 2019

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## List of Abbreviations

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BMC:	Business model canvas
CPO:	Chief procurement officer
ESI:	Early supplier involvement
EASA:	European Union Aviation Safety Agency
KPM:	Kraljic Portfolio Matrix
NPD:	New product development
NRE:	Non-recurring expenses
NA:	Not applicable
PCB:	Printed circuit board
PSM:	Purchasing and supply chain management
RFI:	Request for information
RFQ:	Request of quotation
R&D:	Research and development
RBV:	Resource-based view
TV2:	Test vehicle 2
TCE:	Transaction cost economics

# 1 Introduction

---

Start-ups are not born in a vacuum but arise in an environment full of social, technological, and economic factors. These factors and other actors construct a network. A startup should establish and use relationships within this network to develop and grow (Baraldi, Havenvind, Linné, & Öberg, 2018). Suppliers are among one of the most important actors in this network. First, Song and Di Benedetto (2008) have argued that the participation of suppliers is critical to the existence of new ventures regarding new product development. This is especially the case with radical innovation (Song & Di Benedetto, 2008). Second, supply chain integration has been found to be the most influential success factor for start-ups in a meta-analysis by Song, Podynitshyna, van der Bij, and Halman (2008). The authors have further stated that supply chain integration is an essential aspect of resource accumulation; this integration is key not only for the start-up to require capabilities but also increasingly for the acquisition of investment funding in return for a share of the generated profit (Song & Di Benedetto, 2008). Third, new ventures had better performance, commercialized more rapidly, and increased their potential to expand when they were able to outsource their needed resources, according to a study by Paradkar, Knight, and Hansen (2015). Outsourcing, therefore, is considered to be a capability that is vital for start-ups (Paradkar et al., 2015).

Even though suppliers could be of great value to start-ups, prior research has not addressed how new ventures could build a supply chain to support their business strategy. Only one study, by Song and Di Benedetto (2008), discussed the involvement of suppliers in a new venture's product development. Most of the existing studies in the field of PSM have been primarily concerned with established firms in mature industries (Johnsen, 2009; Mirzaei, 2014a). Moreover, literature about new ventures often does not incorporate PSM at all (Bjørgum & Netland, 2017; Song & Di Benedetto, 2008). Both Bjørgum & Netland (2017) and Song & Di Benedetto (2008) have emphasized that although much of the current literature can be applied to new ventures, these firms face other complicated and unique challenges. Some key challenges for new ventures include: the unwillingness of suppliers to be involved due to high market and technology risk; limited external legitimacy due to limited track records; lack of established contacts; and limited standards (Bjørgum & Netland, 2017; Song & Di Benedetto, 2008). In addition, the objectives of start-ups and established companies also differ. New ventures seek to maximize their chances of long-term survival rather than to maximize profits (Archibald, Thomas, Betts, & Johnston, 2002). These points indicate a significant gap between PSM and literature on new ventures.

The purpose of this research is to better understand how start-ups can build a supply chain to support their business strategy. Since this topic is too expansive for detailed research, this study focusses on three main elements of supply chain management. These elements were derived from the strategic management process towards purchasing excellence (van Weele, 2014) and the cyclical purchasing model (van Weele, van Berkel-Schoonen, & Walhof, 2017). First, these models suggest that companies should question whether items should be produced in-house or outsourced in the market. This consideration is also referred to as the make-or-buy decision. Second, the degree of supplier involvement should be considered for the outsourced items. Supplier involvement was set as the main focus of the study because it appears to be the most critical factor in building a supply chain for new ventures (Song & Di Benedetto, 2008). Finally, the right supplier should be qualified and selected for the purchased parts.

To explore these three topics, PAL-V serves as a case study. PAL-V was founded in 2008 and seeks to bring the world's first commercial flying car to the market in 2020. The company needs a network of suppliers to achieve this goal. Therefore, the main objective of this research is to design a solution for PAL-V's missing supply chain. Our solution will help PAL-V build its supply chain and improve their procurement maturity in order to support the overall business strategy. Although PAL-V's flying car is far from ordinary, the company is experiencing the same challenges as other rapidly growing start-ups, such as the challenge

of entering an established market. Hence, it is expected that the outcome for PAL-V could be used to form a set of coherent organizational design principles that are applicable to other new ventures. The following paragraph will describe the case study company in more detail.

## 1.1 PAL-V

PAL-V inaugurates the age of the flying car by being the first to bring a certified production model to the market. Founded in 2008, Dutch company PAL-V started to develop their first proof of concept. After numerous trials, they succeeded in March 2012 with the PAL-V ONE, a three-wheeled hybrid gyroplane that converts into a car and can carry up to two persons. The PAL-V ONE's first flight proved to be capable of overcoming technical challenges while complying with existing safety standards, as well as car and aviation regulations. The company was subsequently funded by over 100 investors and continued to improve its vehicle. Now, 5 years later, PAL-V is unveiling the Liberty, their new commercial model, to the world. The Liberty comes in Sports and Pioneers editions and the first show model (TV1) has already been produced. The vehicle is in its final development stage and is finishing the certification process. As part of this process, two more vehicles for testing and certification will be produced in the next 2 years (PAL-V, 2018). PAL-V is taking pre-orders and will start delivering once fully certified in 2020. Following Rietdijk (2018a) it is anticipated that production will start with a small production batch, and production will increase rapidly thereafter.

Previously, PAL-V's main emphasis was on engineering activities. Currently, the focus is more evenly distributed among all business functions. Marketing & sales, operations, and the procurement department in particular receive more attention. This is necessary in order to produce the two new vehicles for certification and meet the expected demand after launch. The two main challenges to this development are the level of maturity required by aviation and automotive authorities and global interest. These challenges force PAL-V to build a more mature organization than a start-up normally would (Rietdijk, 2018a). Quality systems, supplier assessments, and traceability are just some examples of PAL-V's necessities (EASA, 2012). Oviatt and McDougall (1995) have stated that conventional wisdom dictates that firms usually internationalize after a period of maturation. Furthermore, the company is growing in size, which may cause internal issues such as a lack of structure. Finally, competition is fierce, and multiple new entries cause high uncertainty (Frost & Sullivan, 2017). Thus, PAL-V's environment can be characterized as turbulent at least. This is in line with Tsai and Lan (2009) who describe a start-up scenario as dynamic, nonlinear, and unpredictable.

The management of PAL-V has set three main objectives that seek to help the company survive in a such a competitive and unpredictable environment during the next phase of commercialization. The first objective is certification of both vehicle and organization. Without either one, PAL-V would not be allowed to sell or produce vehicles. Second, it should be able to fill its order book with a minimum set of sold vehicles. Third, a vehicle's cost price that can support the business model should be established (PAL-V, 2018). The procurement department has been appointed as primarily responsible for the last objective of cost price. This objective together with above mentioned challenges provide an opportunity for a master thesis project.

## 1.2 Problem Statement

Interviews with management and the procurement department were conducted as part of the preliminary research at PAL-V. Notes of these interviews are presented in *Appendix I*. In addition, corporate documents validated some of these interview statements. Based on these findings, an Ishikawa diagram was constructed in consolidation with all stakeholders. The diagram allows for a systematic approach to categorize causes in a pre-defined framework of materials, methods, people, and environmental aspects (Ilie & Ciocoiu, 2010). The results of the approach can be found in *Appendix II*.

Test vehicle 1 (TV1) is used as the benchmark for operation and supply chain performance. Initial analyses of TV1 indicate that current profit margins could not support a profitable business model (Rietdijk, 2018b). This problem was selected for the Ishikawa diagram because it is one of the three main objectives of PAL-V. Two possible causes could be identified. First, it is possible that the sales price of the vehicle is too low. This statement is hard to justify since the vehicle is not officially being sold, and market feedback is therefore minimal. However, the price of €500,000 was set long before the design was finalized. Since then, multiple vehicle systems have been added, and former purchasing agent has classified the initial cost estimation as “*unrealistic, incomplete, and outdated*” (Rietdijk, 2018a). The agent subsequently made a new cost estimation. Nevertheless, the revised estimate is lower than the current cost price which leads to the second possible cause: an exorbitant cost price of which 83% is assigned to material cost and 17% is assigned to labor cost (Rietdijk, 2018b).

High cost of materials might be explained by the nature of flying car components. These parts are mostly custom made for PAL-V, which means minimal use of standardized products, use of special lightweight materials, and stringent product requirements. On top of that, economies of scale could not be achieved in this stage because adjustments will likely still be made, resources were limited, and normal production numbers in the automotive and aerospace industries are far higher. In addition, environmental factors drove costs. Suppliers of these established industries often have more bargaining power because they are larger, provide specific technologies, and limited substitutes are available. Porter has assessed these aspects in his Five Forces model (Burns, 2014). The willingness of these suppliers to cooperate in the development was also limited due to a lack of confidence in the product and firm. However, the method of selecting the vendors might not have been adequate in all cases. Some suppliers have been selected by engineers rather than procurement agents because of time restrictions and an understaffed procurement department. Although this does not necessarily have to be a problem, there was no alignment and purchasing objectives, which meant that the department had to deal with conflicting interests (van Dijk, 2018). Moreover, the young and inexperienced procurement department should have been led by an experienced procurement agent. Unfortunately, the appointed agent could not fully fulfil his task due to personal circumstances, leaving the department to fend for itself. Besides supplier selections, this procurement agent was appointed to bring more structure in operational processes and define an action plan. Furthermore, TV1 had a strict deadline, which caused the procurement department to focus on ordering parts rather than reducing costs. All these factors led to an absence of strategy and operational structure, thereby causing a low profit margin.

Although profit margin was selected for the Ishikawa, this research questioned if the previous mentioned causes could have led to a more important problem. The absence of a strategy or structure would not only affect the cost price of the vehicle but potentially also the non-recurring expenses (NRE) (van Dijk, 2018). PAL-V has defined its NRE as necessary cost for producing parts for the vehicle. Some examples of these costs are composite, measurement or welding molds, jigs, and tooling. These expenses can be significant. Currently, the amount of these expenses as well as their lifespan are unknown. Another effect of not having a strategy or structure in place for the procurement department is the missed opportunity of supplier involvement. With exception of three main suppliers that are involved in the development process, the majority of smaller suppliers are not involved and only provide quotations (van Dijk, 2018). PAL-V wishes to involve suppliers in both the innovation and operational processes. Many researchers have argued that supplier involvement could be beneficial in numerous ways, such as development speed or innovative performance (Luzzini, Amann, Caniato, Essig, & Ronchi, 2015; Menguc, Auh, & Yannopoulos,



2014). Not to mention, PAL-V has not established a supply base for most of its components. Suppliers are not identified, and the contracted vendors are not capable of producing the expected demand by themselves. Finally, PAL-V has a strict deadline for producing its next test vehicle (TV2). This deadline might not be met if suppliers are not able to deliver on time.

Based on these challenges, it is clear that the purchase maturity, as defined by van Weele (2014) in the purchasing development model, is in an early stage. This is common for start-ups with little procurement experience and indicates room for improvement. However, PAL-V faces an additional challenge of having to achieve a mature supply base faster than a normal start-up (Rietdijk, 2018a). Based on these findings the following statement describes the problem statement of PAL-V:

***PAL-V, a highly innovative start-up, is missing a supply chain to support its future business strategy.***

Although compromising on quality, technological, logistics, or timing is a method to reduce cost prices, this solution is impossible. A variety of aspects such as certification, supplier involvement, and scalability are critical for PAL-V. Therefore, this research aims to build a supply chain rather than to solely focus on reducing costs for the firm.

### 1.3 Research Question

The following general research question is defined to determine a solution to the problem statement:

***How can a highly innovative start-up build a future-proof supply chain to support its business strategy?***

Several underlying sub research questions are derived to answer the main research question:

1. How does PAL-V's business strategy look like, now and in the future?
2. How to resolve the make-or-buy decision for PAL-V?
3. How to involve specialist suppliers to both PAL-V's innovation process and operational process?
4. How to qualify and select the right partner for PAL-V?
5. What are the consequences and implications for PAL-V's (procurement) organization and systems?

### 1.4 Research Scope

The scope of the research project covers PAL-V Operation B.V., which in one of the seven business units and responsible for production of the vehicle. More precise, the research focusses entirely on parts for the vehicle such as composite panels and NRE such as the composite molds needed to produce these panels. Maintenance, repair, operations, and service cost are out of scope for this research. This scope was selected based on one of the three main business objectives for PAL-V: establishing a vehicle cost price that could support PAL-V's business model.

Furthermore, PAL-V has employed a strategic buyer who will be responsible for leading the procurement department and bringing more structure to the operational processes. Therefore, the understaffing of the department is treated as a resolved issue for the time being. Some operational processes can affect this research, although vice versa could also be true. These processes will be handled in consultation with the department and documented in the master thesis if needed.

Finally, the scope was refined to focus on the four largest spend commodities. Time restrictions would make it impossible to design a complete supply chain solution. Sensitive data have not been included in the analyses for confidentiality reasons but can be found in the *Appendix*.

## 1.5 Research Approach

This master thesis attempts to achieve both practical and academic value by solving a specific field problem and generalizing its design proposition. This thesis applies the reflective design knowledge-generating process described by van Aken, Berends, and van der Bij (2012). While this process is based on the problem solving cycle, it does not focus solely on solving one specific business problem; instead, it focuses on a generic phenomenon (van Aken et al., 2012). The method follows an iterative approach with multiple design iterations. A general sequential representation of our research framework is depicted in *Figure 2*. The business phenomenon; problem definition; analysis and diagnoses; solution design; intervention; evaluation; and academic reflection phases are executed. The data used per phase are summarized in *Table 1*.

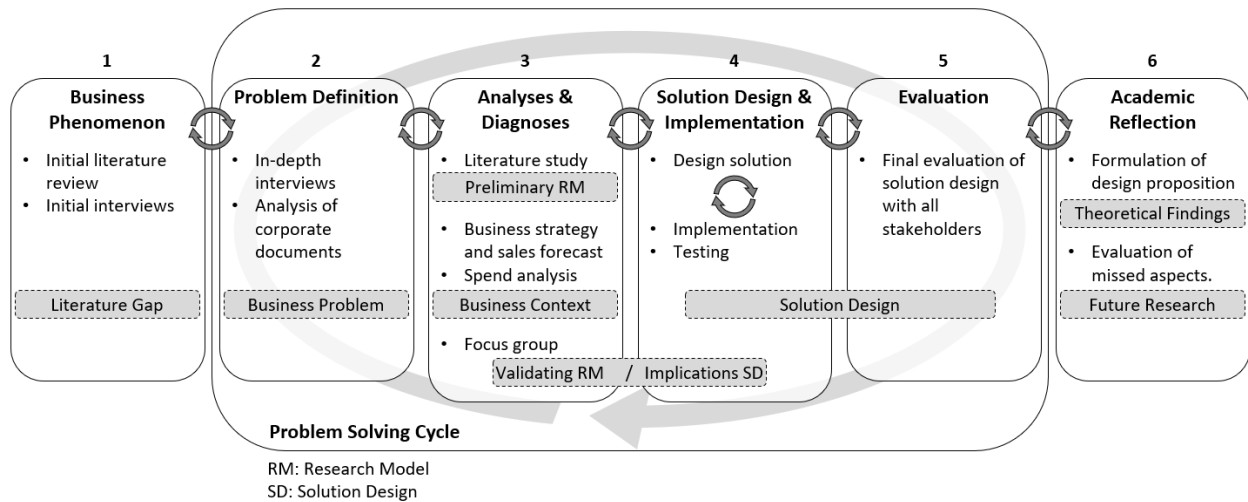


Figure 2: Knowledge generation process adapted from van Aken et al. (2012)

Our ways of working are based upon the principle of “learning-before-doing”, which means that literature will be used during all phases. Literature has helped to gain a better understanding of key factors in supply chain management and guided the research process to define and answer the research questions. However, literature alone is not sufficient for formulating the problem statement. The first and second phase follow an exploratory nature in which pre-understanding is gathered through discussion and interviews. Moreover, some discussion statements could be validated by examining corporate documents. However, the focal firm’s employees and management were the main source of information for increasing understanding of the business case, procurement processes, product, and the organization as a whole. The phases resulted in the definition of a literature gap and the selection of the company’s business problem.

The third phase, analysis and diagnostics, served two purposes: to define a preliminary conceptual research model and to analyze the business context in which PAL-V operates. The preliminary research model, first purpose, serves to guide the solution design. The model was the result of the systematic literature review that followed the overall theme of PSM. Four bodies of knowledge cover the wide field of research related to the problem statement. The first literature category examines the *make-or buy decision*. This category provides insight into a fundamental strategic decision that firms must make and will significantly affect the supply chain. General PSM and top-level strategic literature was studied, to a lesser extent, to broaden this perspective. *Supplier relationship management*, as second category, can be beneficial in numerous ways because PAL-V wishes to involve suppliers in both innovation and operational processes. Third, *supplier selection* was addressed because this is considered to be a vital aspect of supply

chain development (Monczka, Handfield, Giunipero, & Paaterson, 2009). The last category is classified as *start-up literature* or the creation of new ventures. Procurement has been rarely included in this field of research. Nevertheless, it might provide constructs, strategies, or frameworks that could be projected on PSM. This field of research was chosen because the focal firm encounters similar problems as mentioned in the literature.

The second purpose of the analysis and diagnostic phase was to analyze the business context in which PAL-V operates. The research model revealed that understanding this context is vital for the solution design as the solution is directly related to all sorts of business factors. For instance, a supply chain cannot be designed if the company is unaware of how many products will be produced. Analysis of the business context consisted of two parts: mapping the business strategy and sales forecast; and performing a spend analysis. The business strategy is the basis for all supply chain considerations, according to many authors (Batenburg & Versendaal, 2006; Luzzini et al., 2015; van Weele, 2014). The sales forecast complemented the strategy to form a complete future perspective. They were both mapped during a series of management meetings. Here, the business model canvas (BMC) was used to facilitate the discussion. Second, a spend analysis was performed to form an understanding of the supply base, product, and cost price structure. In simplistic terms, this analysis determines where the firm buys what. Clearly, a company could not improve a supply chain without the knowledge of current expenses. Moreover, the analysis could validate the problem statement (too low profit margin) presented by PAL-V. The input for this analysis was formed from meta data of TV1 extracted from the ERP system and supplemented with procurement insight, engineering insight, and corporate documents. Since a general approach for a spend analysis is not defined by academics, the CRISP-DM (cross industry standard process for data mining) principles are adopted as inspiration. This iterative method consist of six steps which allow for consistency, repeatability, and objectivity (Provost & Fawcett, 2013).

An additional step was conducted before the thesis proceeded to the fourth phase: organizing a focus group with PSM field experts. A focus group is a form of interview that explicitly uses group interaction to generate data and are particularly useful to extracting knowledge from participants (Kitzinger, 1995). The objective of the focus group was twofold: to validate the research model derived from the literature research and to gain expert knowledge towards a possible solution for PAL-V. Hence, the step is visualized in the third and fourth phase of the knowledge generating process in *Figure 2*. The group consisted of three chief procurement officers (CPOs) and PAL-V's CEO, research and development (R&D) manager, and strategic buyer. The meeting was co-supervised by purchasing and supply chain professor Van Weele of the Technical University of Eindhoven. The panel, eight in total, gathered at PAL-V for an extensive discussion about pre-defined supply chain topics divided among the research model. Their recommendations were later incorporated into the solution.

Validation of the research model by the focus group was the last aspect of the analysis. The analysis was followed by the fourth phase of solution design and implementation. The design sequence adapted the general design process by van Aken et al. (2012) complemented with the design science approach (Keskin, 2017) to come to a solution. Hence, the design underwent multiple design iterations where the results were presented to the organization on a weekly basis. The research model served as guidance, and the procurement department, management, and engineers were all closely involved. Iterations had a double purpose as they simultaneously evaluate and create acceptance towards the solution design. Therefore, fifth step of the evaluation phase only consisted of one final review with all involved stakeholder.

The last phase of research methodology is the academic reflection, during which theoretical design propositions are proposed. In addition, recommendations for future research are provided. No additional data was used in this phase.

Table 1: Data per phase of the knowledge generating process

#	Knowledge generating process	Data	Comment
1	Business phenomenon	Informal discussions with procurement department and management	Daily, 15-60 minutes per conversation
		Academic literature	>30 papers
2	Problem definition	Informal discussions with procurement department and management	Daily, 15-60 minutes per conversation
		In-depth interviews with procurement agent and R&D manager	Twice, 1.5 hour per interview
		Corporate documents	>10 documents.
3	Analysis and diagnoses	Academic literature	>75 papers
		Management meetings	7 times, 1 hour per meeting.
		Informal discussions with procurement, engineering, and management	Daily, 15-60 minutes per conversation
		Meta data ERP system	Meta data of ordering and producing TV1
		Corporate documents	>20 documents
		Focus group	Once, 5 hours
4	Solution design and implementation	Interactive meetings with procurement, engineering and management	Predominantly procurement and engineering. Weekly, 1.5 hour per meeting
5	Evaluation	Informal discussions	Daily, 15-60 minutes per conversation
		Final evaluation meeting	Once, 2 hours
6	Academic reflection	Previous generated data	-

## 1.6 PAL-V as a Start-up

Although PAL-V was established back in 2008, the company can still be perceived as a start-up based on the following reasons. First, the firm remained relatively small (<30 employees) until 2016 due to a strong focus on R&D activities. Hence, the procurement department became operational after the design entered the final development stage. This means that the maturity of the supply chain is still young. Second, the company produced one test vehicle for which non-applicable suppliers were used. These suppliers did not have to meet all aerospace regulations which made prototyping faster and cheaper. Third, PAL-V cannot be compared to academic definitions of new ventures because literature does not clearly defines one. Therefore, PAL-V is predominantly more similar to a new venture than a matured firm. Hence, a case derived from PAL-V can contribute to the literature on start-ups and supply chains.

## 1.7 Report Outline

This research contains six chapters. Chapter 1 “Introduction” introduces the research topic, the business context, research objective, and research approach. It does so by stating a literature gap, problem statement, research questions, and research model. The chapter represents the first two phases of the design science approach.

Chapter 2 “Theoretical Background” presents the literature review of the four bodies of knowledge: make-or-buy decision, supplier relationship management, supplier selection, and start-up literature. These topics provide the theoretical knowledge to resolve the problem statement. A conceptual model is presented at the end of the chapter to guide the solution design. The chapter represents the first objective of the analysis phase, which is to define a research model.

Chapter 3 “Business Context to Facilitate Solution Design” fulfils the second objective of the analysis phase, which is analyzing the business context. This chapter presents the research methodology and the results of mapping the business context, sales forecast, a spend analysis. Moreover, the results from the focus group are discussed.

Chapter 4 “Solution Design and Implementation” is directed to the fourth and fifth phase of the knowledge-generation process. The research model is brought into practice to design a solution for PAL-V’s missing supply chain. The chapter also elaborates on the implementation and evaluation of the design within the organization.

The theoretical and managerial implications of the study are discussed in chapter 5 “Discussion and Conclusion”. In addition, the chapter answers the research questions. This chapter covers the final conclusion of the study. Limitations and possibilities for further research are discussed in the last chapter, chapter 6 “Limitations & Further Research”. Both chapter 5 and 6 represent academic reflection, which is the last phase of the knowledge-generating process. Confidential information is included in the Appendix.

Figure 3 below depicts the graphic representation of the report outline.

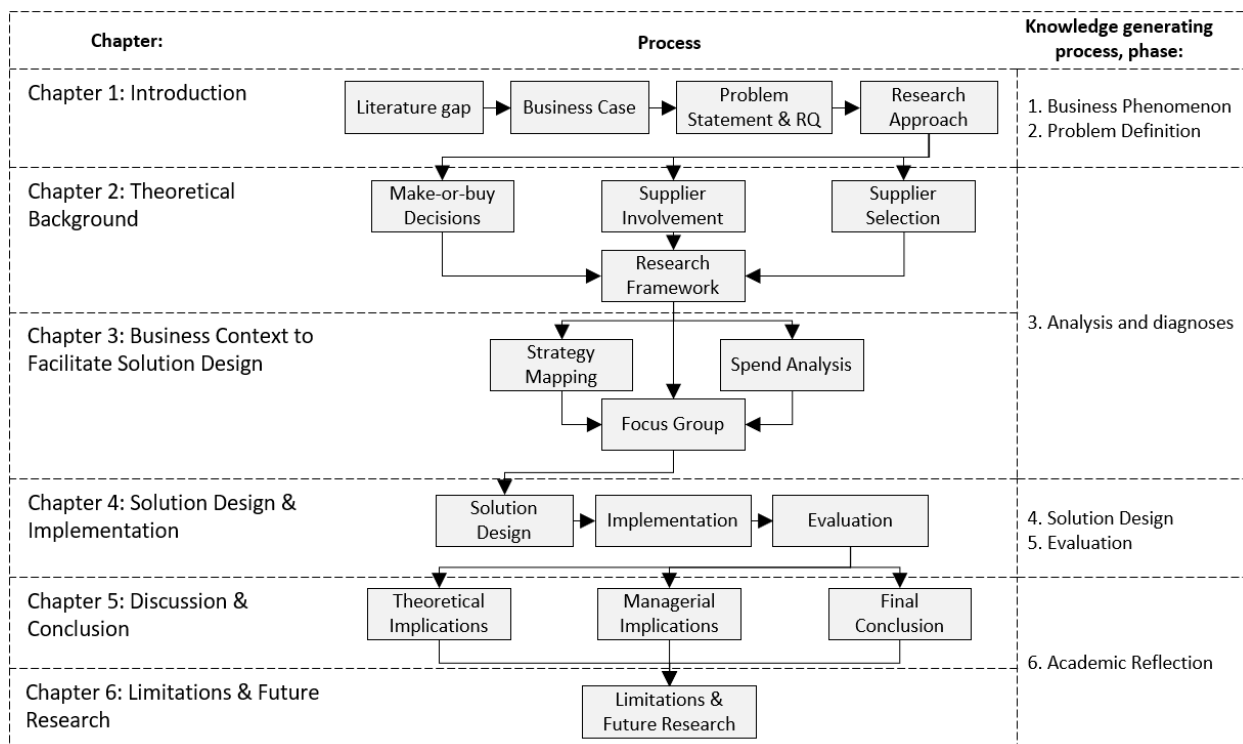


Figure 3: Graphical representation of report outline

## 2 Theoretical Background

### 2.1 Literature Methodology

This section elaborates on the methodology used to construct the literature review. The review started with reading several books regarding procurement, supply chain management, and new venturing. The books provided a comprehensive overview of these bodies of knowledge. This knowledge base served as guidance to select the first keywords for the literature search. Scopus was used for the first search, with the keywords *procurement*, *purchasing*, *suppliers* or *supply chain management* in combination with *new venturing* or *start-ups*, which did not yield many results. The approach was modified to a specific search in new venture journals (Journal of business venturing; entrepreneurship theory and practice; and journal of business venturing insight) for PSM related concepts. Furthermore, a forwards reference search was performed with the article of Song and Di Benedetto (2008). Neither method yielded relevant articles. This outcome was not surprising as the literature gap already suggested that there has been limited research regarding both PSM and new ventures. Thus, finally, each topic was researched separately and then compared afterwards.

Both topics were examined with an iterative literature research approach, meaning search queries were adjusted gradually. In addition, backward and forward reference searches on the most relevant articles were performed. Scopus was used as the search engine, and all papers had to be in English. The searches for new venture literature were related to the main characteristics and challenges for start-ups. Various searches were performed for PSM, separated into three categories: make-or-buy decision, supplier involvement, and supplier selection. The search for supplier involvement was more extensive than for the other topics since preliminary research suggested its relevance to new ventures. However, all topics were adequately addressed, and a meta-analysis was found for each. *Table 2* presents some of the search phrases.

*Table 2: Keywords for the literature search.*

<b>New venture</b>	<b>Make-or-buy</b>	<b>Supplier involvement</b>	<b>Supplier selection</b>
New venture OR Start-up OR Entrepreneurial firm OR New business OR New firm	Make-or-buy decision	NPD OR New product development Or Product development	Supplier OR Vendor OR Partner
AND	OR	AND	AND
Challenges OR Threats OR Success Factors OR Survival	Insourcing OR Outsourcing	Involvement OR ESI OR Integration OR Partnership	Selection OR Qualification
OR		AND	
Characteristics OR Aspects OR Attributes		Supplier OR Purchasing OR Procurement	

The iterative approach resulted in a thorough overview of academic papers. The papers were sorted based on citations, followed by a first screening of the title and abstract of the article. The relevant articles were downloaded and reviewed in more detail for a second time. Older articles have a higher number of citations, so the search was modified to correct for this and find relevant newer papers. The timeframe was based on the most recent meta-analysis for the topic. An example of a search syntax is presented below.

( TITLE-ABS-KEY ( Procurement OR "Supplier Involvement" OR Purchasing OR PSM OR "Supply chain management") AND ("New venture" OR "New firms" OR "Entrepreneurial firm" OR Startup OR "Start-up" OR "Start up" OR "New business" OR "New firm")

## 2.2 Procurement, Supply Management, and Start-ups

This study takes a PSM perspective towards start-ups and their suppliers. Therefore, the basic constructs are defined first. Scholars use a variety of constructs for PSM to address elements within the management philosophy, such as integrated purchasing strategy, buyer-supplier partnerships, allying, sourcing, supply base management, and supply-chain synchronization (Monczka et al., 2009; Tan, 2001). Small differences within the construct are irrelevant for this study, which adopts the definition by van Weele (2014), who defines procurement as:

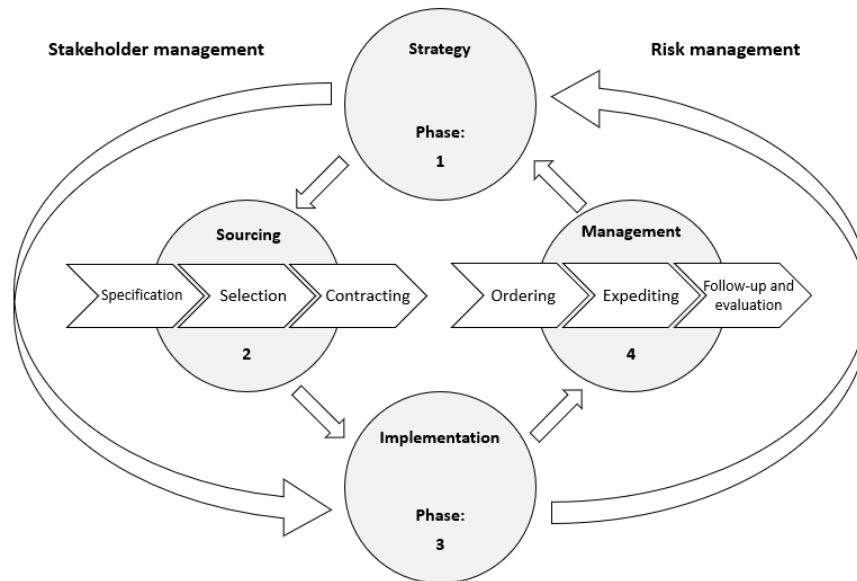
*"The management of the company's external resources in as such a way that the supply of all goods, services, capabilities, and knowledge which are necessary for running, maintaining, and managing the company's primary and support activities is secured under the most favorable conditions."* Supply chain management is defined as *"The management of all activities, information, and knowledge, and financial resources associated with the flow and transformation of goods and service up from the raw materials suppliers, components supplier, and other suppliers in such a way that expectation of the end-users of the company are met or surpassed."* (van Weele, 2014)

In contrast to PSM, a clear definition of a start-up is lacking in academic literature. Most authors do not define start-ups or new ventures, as the terms are self-explanatory. However, Battistella, Toni, and Passot (2017) provide a definition for a start-up as *"an organization created to search for a business model that is scalable, as the customer base should be easy to increase, resulting in a gain greater than the expenditure for customer acquisition, repeatable in time and profitable in terms of return on invested money"*. Remarkably, the definition does not include any values such as years since founding, the number of employees, or annual turnover. Synonyms for start-ups include new ventures, new firms, and entrepreneurial firms. These firms are characterized by their small size, lack of resources, and limited connectedness to their network, all due to their "newness". Nevertheless, when it comes to agility, start-ups outperform established firms (Battistella et al., 2017). These start-up characteristics are similar to the main challenges faced by new business. Battistella et al. (2017) reviewed over twenty determinant factors for start-up failure or success. One main factor was finding partners for resources to increase the probability of survival (Battistella et al., 2017).

Both PSM and start-up literature acknowledge resources as a crucial aspect within their separate constructs. New ventures have limited resources, and PSM strives to ensure resources for the most favorable conditions.

## 2.3 Building a Supply Base

A new-task situation (new product and unknown supplier) occurs for all transaction within a start-up. This situation is characterized by a high degree of uncertainty and risk due to unknown specifications. Various disciplines across hierarchical levels are involved in the decision-making process. This unique case is one of few situations that involves all steps of the purchasing process (van Weele, 2014). The cyclical purchase model, illustrated in *Figure 4*, by van Weele et al. (2017) describes this process. It includes four phases: strategy, sourcing, implementation, and management, as well as two conditions: stakeholder and risk management. All of these elements are interconnected and follow a logical order. This model evolved from the linear purchase model by van Weele (van Weele, 2014), which is incorporated into the second and fourth phase. A brief overview of the cyclical model is presented below as this exemplifies all the phases that new ventures follow.



*Figure 4: The cyclical purchase model.*

First, a purchasing team is assembled in phase 1, strategy. The team starts with an initial spend analysis of the organization. This stage identifies the needs and considers environmental factors. A purchasing strategy (i.e. category or commodity sourcing plan) is defined based on this information. Among the choices are in- or out-, single or multiple, and local or global sourcing (van Weele et al., 2017). The make-or-buy discussion is particularly important for start-ups (Bjørgum & Netland, 2017), which will be reviewed in the following paragraph. Van Weele et al. (2017) emphasize that a purchasing strategy should always be aligned with the corporate mission, vision, and strategy which is supported by many scholars (Batenburg & Versendaal, 2006; Monczka et al., 2009; Virolainen, 1998).

The sourcing phase identifies and selects suppliers. The process starts with specification and a request for information (RFI) or request for quotation (RFQ). Hereafter, a supplier is selected based on in-depth comparison and selection criteria. The most suitable supplier is eventually contracted. The phases match the specification, selection, and contracting steps of the linear process (van Weele et al., 2017).

The third phase, implementation, secures the earlier stages by monitoring agreements. Activities include: creating the supplier in the administrative system, checking procedures, setting key performance measures, and documenting contracts. Often, this phase is more troublesome than previously anticipated (van Weele et al., 2017).



The fourth and final phase, management, includes the last three steps of the linear model: ordering, expediting, and evaluation. It becomes clear that the procurement process does not stop when supplies are ordered. Contract and supplier management are essential to complete the model and will serve as input for the strategic phase (van Weele et al., 2017).

Besides the four phases, two conditions need to be met in order to execute all phases properly. Stakeholder management cannot be ignored since multiple people, with different needs, should be convinced, advised, or informed. Furthermore, risk management is vital for recognizing and evaluating risks so that the appropriated countermeasures can be taken. Although many variations on the purchasing process exist, all incorporate a thorough study of the company and supply market before other decisions are being made (van Weele, 2014).

Another cyclical model is the strategic management process towards purchasing excellence by Monczka (van Weele, 2014). This approach does not represent purchasing steps but rather processes that need to be in place in order to leverage a supply chain strategy. However, as can be seen in *Figure 5*, it involves eight steps that are somehow similar to that of cyclical purchasing model. Insourcing/outsourcing and commodity strategies were both included into the strategic phase where establishing a supply base and managing relationships are comparable to phase 2, sourcing. Hereafter follow multiple managing and integrating steps that could be projected on last phases or the conditions. Both models imply that new ventures should consider in/outsourcing, supplier involvement, relationship management, and supplier selection in order to establish a supply base.

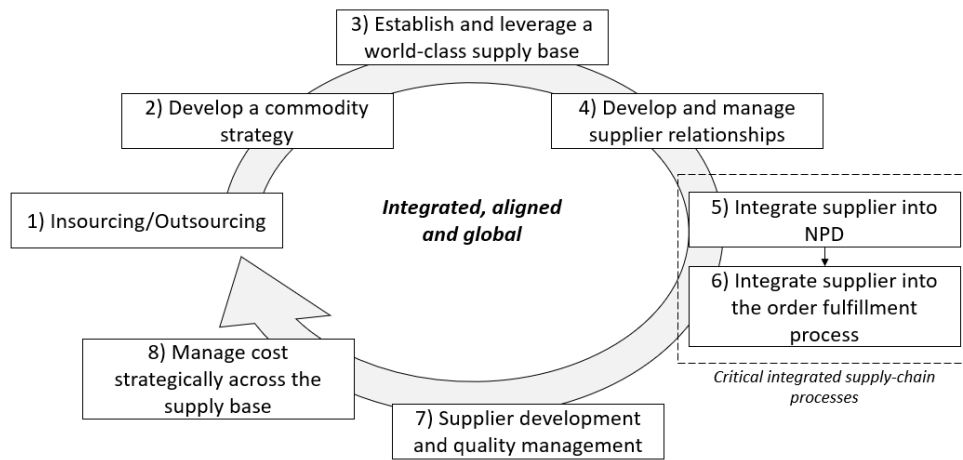


Figure 5: Strategic management process towards purchasing excellence adapted from van Weele (2014).

## 2.4 The Make-or-Buy Decision

A fundamental question regarding PSM for new ventures is to produce in-house or to outsource from the market. This question, referred to as the make-or-buy decision is addressed in the first phase of the cyclical purchasing model. To answer this question, our research draws on transaction cost economics (TCE), which has become the predominant theory for guiding organizational boundary decisions (Geyskens, Steenkamp, & Kumar, 2006). Transaction cost economics, introduced by Williamson, assumes that market governance (outsourcing) is favored over vertical integration (in-house) due to market competition when transaction costs are absent or low (Rindfleisch & Heide, 1997). Although the original TCE framework is only divided into make-or-buy, the current theory also involves relational (ally) and hybrid mechanisms (Geyskens et al., 2006; Rindfleisch & Heide, 1997). In their meta-analysis, Geyskens et al. (2006) discuss how asset specificity, uncertainty, and transaction frequency can raise transaction costs, leading to market failure. The first dimension, specificity, refers to assets that are tailored to a particular transaction. The second dimension, uncertainty, arises from the inability to forecast volume (volume uncertainty), predict technical requirements (technical uncertainty), or verify compliance with the established agreements (behavioral uncertainty). Behavioral uncertainty arises from the assumption that some actors are opportunistic. The last dimension, frequency i.e. recurrence of transactions, has received less attention in the literature. The study revealed that hierarchical governance was more effective than market governance when asset specificity, volume uncertainty, and behavioral uncertainty were high. In contrast, market governance is preferred when technology uncertainty increases. Relationship governance was favored less when there was a higher degree of uncertainty. Geyskens et al. (2006) conclude that favoring governance over relationship might be due to the network of the transactions. As such, the firm should form multiple alliances to prevent lock-in effects, making relational governance a more suitable alternative to market governance in the face of high volume or technical uncertainty (Geyskens et al., 2006). On the contrary, Song and Di Benedetto argue that this lock-in effect due to specific investments can be viewed as a favorable situation for new ventures since this builds trust between the supplier and firm.

Alternatively, Romneland-Wikhamn and Knight (2012) believe that TCE has limitations concerning open innovation, which seems much better explained by relational governance. They emphasize that focusing on coordination cost and the risk of opportunistic behavior by those outside the firm are significant threats to collaborative relations since this supports hierarchical governance. Instead, they argue that a combination of TCE and real options reasoning leads to greater decision making about involvement and partnering under conditions of uncertainty (Remneland-Wikhamn & Knights, 2012). Similarly, Eisenhardt and Schoonhoven (2016) state that TCE does not capture the strategic and social factors that drive many firms to form alliances. They adapt the resource-based view (RBV) rather than TRE to guide cooperation motives. The RBV is a managerial framework in which a firm's competitive advantage lies in the utilization of valuable tangible and intangible resources, both within and outside the firm's disposal (Sjoerdsma & van Weele, 2015). Compared to TRE, the RBV emphasizes characteristics of the firm over transactions, strategic and social factors over transaction cost, and the firm's need over efficiency. Thus, RBV broadens the complex view on alliancing (Eisenhardt et al., 2016).

Other rationales for considering outsourcing over in-house production are provided by van Weele (2014). These reasonings may range from strategic to more tactical. Strategic aspects are those focused on the company's overall objectives whereas tactics target day to day problems to promote this larger strategic vision (Hogan, Hogan, & Barrett, 2007). For instance, outsourcing to improve company's focus, increase flexibility, or share risk are strategic. Tactical reasons might be to free up internal resources or improve performance. Moreover, the consideration can be capacity or expertise related. Meaning that a firm might not process the capacity or specialist skills to produce a given item in-house (van Weele, 2014). This

delicate matter can be addressed by the outsourcing matrix which provides purchasing managers with some guidelines. The matrix, as can be seen in *Figure 6*, shows that the make-or-buy decision depends on two variables: strategic importance of competence and the level of competitiveness relative to the supplier. When a company has high competitiveness relative to its supplier and the competence differentiates the company from its competitors, it should invest to keep that competence in-house. Conversely, capabilities that score low on both values should be considered for outsourcing. Activities which are not strategic important but provide important advantages might be produced in-house as long as the company can achieve a competitive level. Lastly, a firm would benefit from a partnership if the competence is strategic important but not a core activity to the firm (van Weele, 2014).

Level of competitiveness relative to suppliers	High	<p><b>Maintain / invest (opportunistically)</b></p> <p>Competencies are <b>not strategic</b> but provide important advantages; keep in-house as long these advantages are (integrally) real.</p>	<p><b>In-house / invest</b></p> <p>Competencies are <b>strategic and world-class</b>; focus on investment in technology and people; maximize scale and stay on leading edge.</p>
	Low	<p><b>Outsource</b></p> <p>Competencies have <b>no competitive advantage</b>.</p>	<p><b>Collaborate / maintain control</b></p> <p>Competencies are <b>strategic but insufficient to compete</b> effectively; explore alternative such as partnership, alliance, joint-venture, licensing, etc.</p>
		Low (Non-core)	High (Core)

Figure 6: The outsourcing matrix adapted from van Weele (2014)

Van Weele (2014) further emphasizes that organizations should realize that their risk profile changes when they move activities from in-house to outsourcing. Advantages and disadvantages of outsourcing are presented in *Table 3*, to further elaborate on risk aspects.

Table 3: Advantages and disadvantages of outsourcing adapted from van Weele (2014)

#	Advantages	Disadvantages
1	Freeing up cash: investments can be concentrated on core activities	Increased dependence on suppliers
2	Optimal usage of knowledge, equipment, and experience of third party	Continuous follow-up and monitoring of the supplier relationship is necessary
3	Increased flexibility: Fluctuations in the workload can more easily be absorbed	Risks of communication and organizational problems during the transfer of activities to a third party
4	Outsourcing leads to easier and more focused primary processes in the organization	Risk of leakage of confidential information
5	Input through an independent party's point of view which reduces the risk of introvert short-sightedness in the organization	Depending on balance of power between parties: inability to execute contractual performance incentives and penalties
6		Risk of losing essential strategic knowledge

From the studies above, it can be concluded that TCE can be used as a fundamental framework to guide make-or-buy decisions, as it assesses a robust set of transaction aspects. However, considerations for alliances are more complex and demand a broader perspective. Here, the RBV can provide an expanded view as a complementary framework. Moreover, the company should examine if competences are strategic important and can be performed on a competitive level relative to its supplier.

## 2.5 Supplier Involvement in New Product Development

The purchasing strategy, phase one of the cyclical model, involves more than just addressing the make-or-buy decision. A second fundamental question is how to involve suppliers for the outsourced parts. For new ventures, this automatically means involving suppliers in the new product development (NPD) process. This section explains the following concepts: motives for supplier involvement, the timing of involvement, the responsibility of suppliers, and collaboration aspects.

### 2.5.1 Motives for Involving Supplier in NPD

Globalization and a rapidly changing world push firms to shorten their time-to-market, while simultaneously improving product quality and reducing costs (Ragatz, Handfield, & Scannell, 2003a). A challenge that is not easily met by firms alone. Therefore, firms started to involve suppliers earlier and more closely within their NPD process (Mirzaei, 2014b). Prior research has shown that involving suppliers can yield benefits, such as reducing cost, improving quality of supplies, reducing product development time, improving access to and application of knowledge, and sharing of risk (Mirzaei, 2014a; Ragatz, Handfield, & Scannell, 2003b). Wynstra (1998), for instance, reasoned that suppliers have specialist development potential, making their development activities more efficient. Furthermore, supplier involvement is not only beneficial to established firms. Song and Di Benedetto (2008) emphasized that involvement in radical innovation might be even more critical for new ventures. However, simply involving the supplier does not guarantee better NPD performance. In fact, Johnsen (2009) found fragmented research and conflicting empirical findings of the effectiveness of projects that involved the supplier in NPD. The author concluded that from a supplier perspective, there is evidence to suggest that powerful customers behave opportunistically and may ruin trust which is critical to success. Nevertheless, the majority of evidence supported that early supplier involvement (ESI) is a key factor for superior NPD performance (Johnsen, 2009). Mirzaei (2014a) expanded on Johnsen's work and found less contradictory results. As opposed to older articles, all new ones from 2009 to 2014 showed benefits for ESI. Therefore, Mirzaei argues the importance of performance, coordination, communication, and knowledge exchange to foster NPD collaboration. Furthermore, the study identified many supplier characteristics and the importance of supplier selection. Van Weele (2018a) supports this and states that many challenges across strategic, operational, and collaborative management processes need to be addressed. Therefore, ESI has the potential to increase NPD performance if managerial challenges are overcome. The following paragraphs will discuss which challenges arise and how to overcome these challenges.

### 2.5.2 Timing of Supplier Involvement

Several challenges regarding supplier involvement in NPD should be resolved. At first, managers should consider when to involve suppliers into the NPD process. Wynstra (1998) states that suppliers can prevent or at least reduce design changes if they provide information. Changes could affect both cost and delays as a result of rework. The later the change is executed in the development process, the higher the negative the impact, as the specifications have been previously set. Even worse, parts could already be in production (Wynstra, 1998). *Figure 7* shows how development time, the degree of purchasing freedom, level of specification, and cost of change all interact.

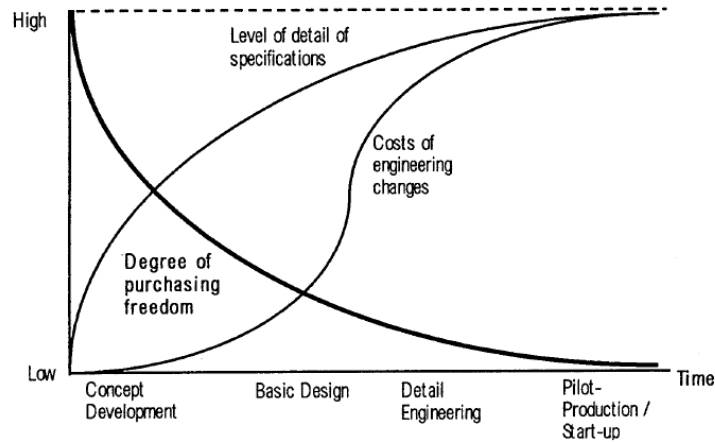


Figure 7: Room for achieving cost reduction through product design (Wynstra, 1998).

It becomes clear that when the project matures, purchasing's degree of freedom declines while the cost of engineering changes increase. This relationship between the cost of change and purchasing freedom would suggest that it is beneficial for the involvement of the suppliers to be involved as early as possible. Several researchers agree that earlier involvement is always better (Petersen, Handfield, & Ragatz, 2005). Although research shows that earlier involvement is beneficial when technology uncertainty is high, this view could be countered by the disadvantages of a lock-in situation (Petersen et al., 2005). Van Weele (2018a) recommends discussing timely rather than early supplier involvement, as the right time and right level of responsibility should be based upon the capabilities of the supplier. In other words, it would not make sense to include a supplier early in the concept stage if he is instructed to make a part according to strict technical specifications (e.g. drawings). On the other hand, if the supplier is requested to design a product based on some performance specifications, it would be logical to integrate him earlier. The level of responsibility clearly differs. The next paragraph will further elaborate on supplier responsibility.

### 2.5.3 Supplier Level of Responsibility

Not all parts require the same level of responsibility and involvement from the supplier. Monczka, Handfield, Frayer, Ragatz, and Scannell (2000) developed a spectrum to classify the level of supplier responsibility. At the lowest level, none, a supplier is not involved and executes a given order based on a technical specification. The white box supplier (second level) will consult on the buyer's design, whereas grey box (third level) suppliers are integrated into joint development activities. The highest responsibility level is black box design, meaning that the design is primarily supplier-driven, based on the buyer's performance specifications (Monczka et al., 2000). Wynstra and Pierick (2000) introduced the supplier involvement portfolio to distinguish four types of supplier involvement, based on the degree of responsibility and development risk. Here, risk is defined as the importance, newness, and complexity of successful development. The portfolio serves as a guideline to setting up appropriate relationships and communication between buyer and supplier. *Figure 8* provides an overview of these guidelines.

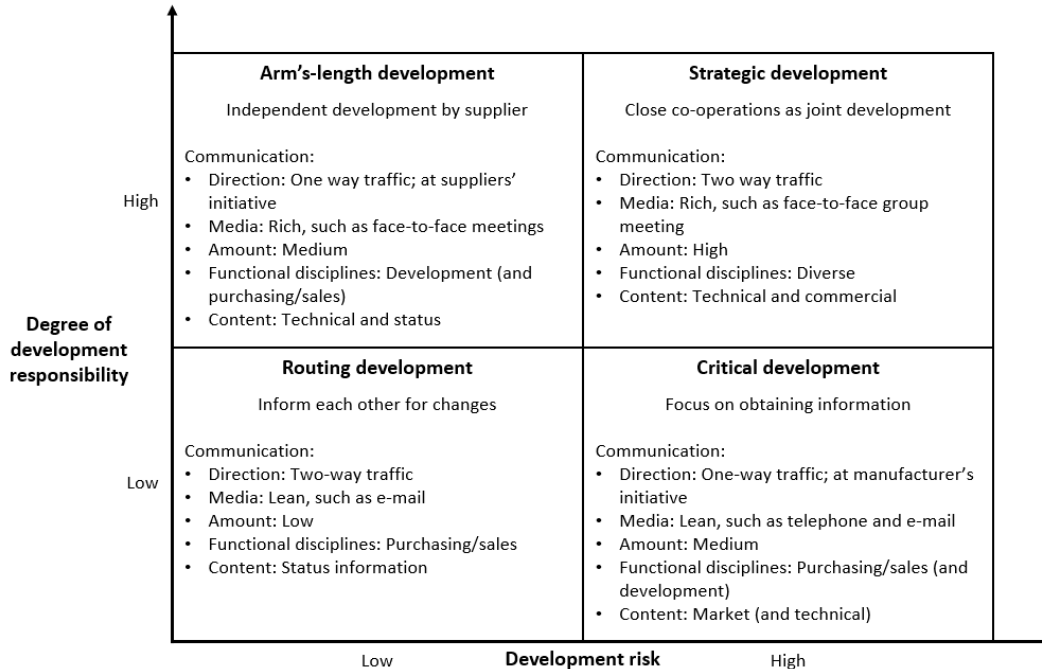
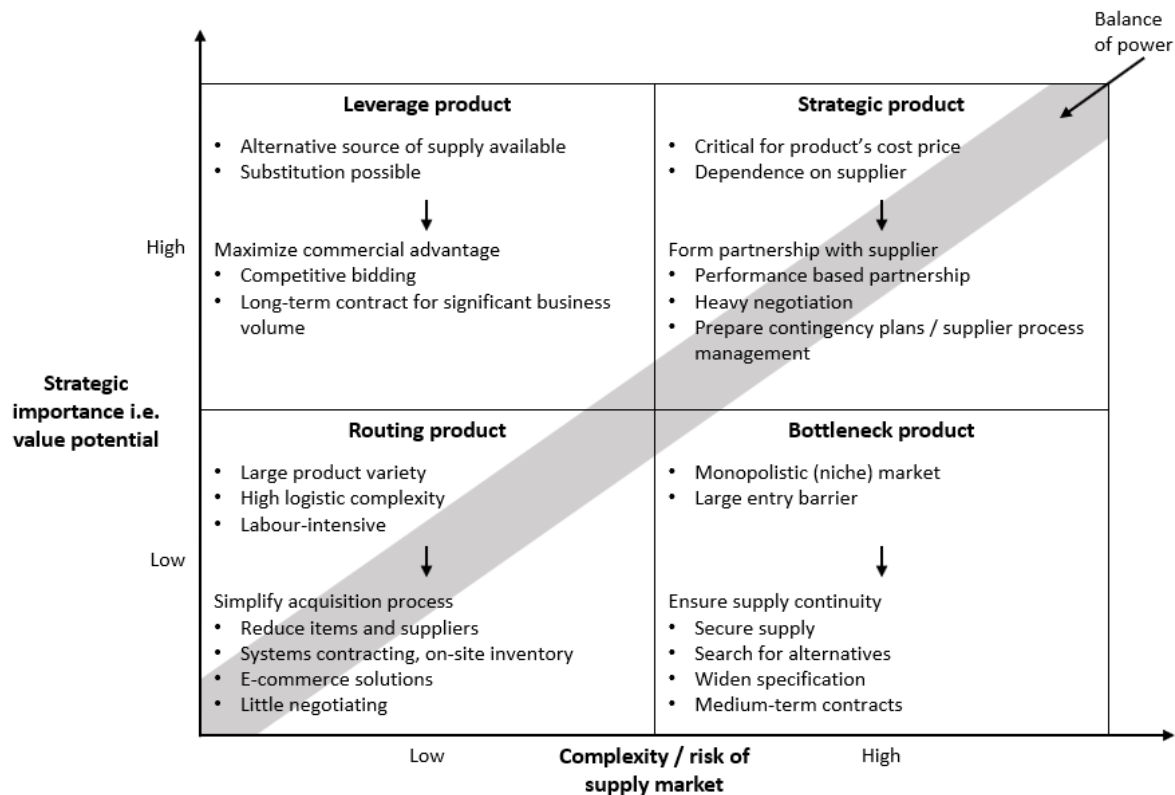


Figure 8: Supplier involvement portfolio adapted from Wynstra & Pierick (2000).

Strategic development requires close and interactive collaboration as both development risk and supplier responsibility are high. Therefore, communication lines should be short so that problems can be adequately addressed. Preferably, this is done with regular face-to-face communication, in which both parties can explain what is desired and possible. This situation could occur for a supplier that is involved in the concept development phase. For critical development, where development risk is high, but the supplier responsibility is low, the manufacturer is dependent on information of the supplier in an early stage. Near-standard parts, which could be critical interfaces for the overall design, could serve as an example. Here, limited communication through 'lean' media (e.g., e-mail) is sufficient to request concrete information. The buyer is in the lead as he perceives high uncertainty, while the supplier may not have the same view. Arm's length development occurs when a significant part is outsourced to the supplier, but the development risk is considered minor. Therefore, the buyer will not feel the urge to be closely involved, and as a result, often provides rather vague information. Rich communication media is desired, especially in the beginning, and the initiative should come from the supplier. Communication frequency is less compared to strategic development. Routine development, the last category, is characterized by both minimum development risk and minimum supplier responsibility, such as when the manufacturer has already developed the product and only needs it to be produced. Hence, the two parties should keep each other apprised of any changes, costs, and specifications. Lean media is sufficient for this contact and communication frequency can be kept to a minimum while a face-to-face meeting once a year is advisable to "stay in touch" (Wynstra & Pierick, 2000).

Another widely used approach for structuring the supply base is Kraljic Portfolio Matrix (KPM). The KPM is comparable to the supplier involvement portfolio of Wynstra and Pierick: both are visual tools that consist of a two-dimensional matrix where four quadrants guide strategic procurement (Montgomery, Ogden, & Boehmke, 2017). Kraljic (1983) argues that the supply strategy for different products relies on two factors: the strategic importance of purchasing (i.e., value potential in terms of percentage of total purchasing spent) and the complexity of the supply market (i.e., risk in terms of availability and competitive demand). These terms are hereafter referred to as value potential and risk, respectively. The

four quadrants of the KPM are leverage products, strategic products, routine products, and bottleneck products. Each quadrant requires a distinctive purchase approach as can be seen in *Figure 9*.



*Figure 9: KPM adapted from van Weele (2014).*

Leverage products (high value potential, low supply risk) provide the opportunity for savings, as they are readily available and internal consumption is high. As leverage products are amply available and supplier many, this minimizes switching cost and allows for complete bidding or e-auctions. Cost reduction can be achieved by rewarding suppliers a significant volume of the business units in a long-term agreement. This agreement could also ensure quality objectives. Raw materials, standard commodities, and bulk chemicals could serve as an example. Strategic, or critical, products (high value potential, high supply risk) are often customer-specific and are used to gain a competitive advantage. These items represent a considerable portion of the cost price, and alternative suppliers cannot easily be found. Thus, strategic cooperation between supplier and buyer is preferred. Routine products (low value potential, low supply risk) do not provide any challenges, as many alternative suppliers and a low value characterize these items. Procurement should optimize the purchasing process to minimize cost. The reduction of items and suppliers, on-site inventory, and standardization might provide a solution for improving this process. Office supplies and cleaning materials are some examples of routine products. Bottleneck products (low value potential, high supply risk) can only be obtained from a niche supplier, but do have not an enormous financial impact. Exclusive materials, such as spare parts, fall into this category. The goal is to secure materials, which can be done by developing agreements with suppliers. Ideally, subsites are found to make the firm independent of such products (Kraljic, 1983; Monczka et al., 2009; van Weele, 2014). The essence of KPM is captured in Figure 5, which is adapted from van Weele (2014).

Despite the widely held consensus that KPM provides useful guidelines, there are concerns with the model (Montgomery et al., 2017). Specifically, Montgomery et al. (2017) indicate problems with subjectivity in measurement dimensions, failure to account for interdependencies between products, and a disregard of the supplier side. The final concern is reinforced by van Weele (2014) who states that the positioning of a product does not necessarily imply that a supplier shares the same view. A good fit and understanding of the relationship between two parties are needed to develop effective collaboration (van Weele, 2014). Van Weele (2014) suggests mirroring the supplier's view by using the Dutch Windmill. Either the buyer or supplier will be dominant in most cases, which is valuable to realize during a partnership (van Weele, 2014). Kraljic (1983) does, however, state that a firm should rely on its bargaining power and strength as a customer to identify which products can be exploited, diversified, or balanced.

To summarize, two models were reviewed. First, the supplier involvement portfolio serves as a guideline to establish relationships and communication between buyer and supplier. It does this by examining the degree of development risk and degree of supplier responsibility. Second, the KPM segments the supply base by value potential and supply risk, which provides a strategic guideline for each quadrant. Nevertheless, subjectivity and the supplier's perspective should be kept in mind when using the tool.

#### **2.5.4 Procurement Function, Collaboration, and Knowledge Sharing in ESI**

A third challenge is to organize the procurement function in such a way that it can support NPD while simultaneously managing overall cost (Schiele, 2010). This is not an easy task since it involves human interfaces that usually operate in a setting with conflicting interest (van Weele, 2018a). Several perspectives and classifications were found in prior research to address this challenge (Lakemond, van Echtelt, & Wynstra, 2001; Schiele, 2010; van Weele, 2018a). This study draws on the perspective of van Weele (2018a) as he defines, in contrast to others, a top-down approach with limited interacting constructs. The author found the ESI operates at four different levels: the organizational level, the project level, the relationship level, and the individual level. In this review, the organizational level was replaced by the strategic level, as inter-organizational challenges were discussed earlier and strategic alignment was not.

##### **The Strategic Level**

The strategic phase of the cyclical purchasing model already mentions the importance of aligning the corporate and procurement strategy. Luzzanni, Amann, Caniato, Essig, and Ronchi (2015) found that this alignment is critical for ESI as well. They made a distinction between operational, project-related short-term settings and strategic, long-term settings. The authors concluded that the latter, as a category priority, leads to increased innovative performance. In other words, an innovative strategy will enable supplier collaboration. However, managers should consider individual and sometimes conflicting objectives at the category level before integrating such a strategy (Luzzini et al., 2015). A useful tool for alignment was proposed by Schiele (2010), who states that a technology roadmap could not only link the strategic objectives but also align commodity groups and guide supplier selection.



## Project Level

If suppliers are involved in the NPD process, then the procurement department is often assigned as a relationship manager or liaison role. However, different projects require different organizational mechanisms (Lakemond et al., 2001). Lakemond et al. (2001) defined six possible configuration mechanisms that involve purchasing in NPD, which can be found in *Figure 10*. The project complexity and project size are also important factors in the configuration mechanism. Complexity is caused by the number of various expert fields required, whereas project size refers to the number of participants. As an NPD project increases in size, it is expected that permanent members are added to the project. More in-depth project involvement is possible at configuration A, B, and C, whereas configuration D, E, and F provide an opportunity for a higher degree of coordination.

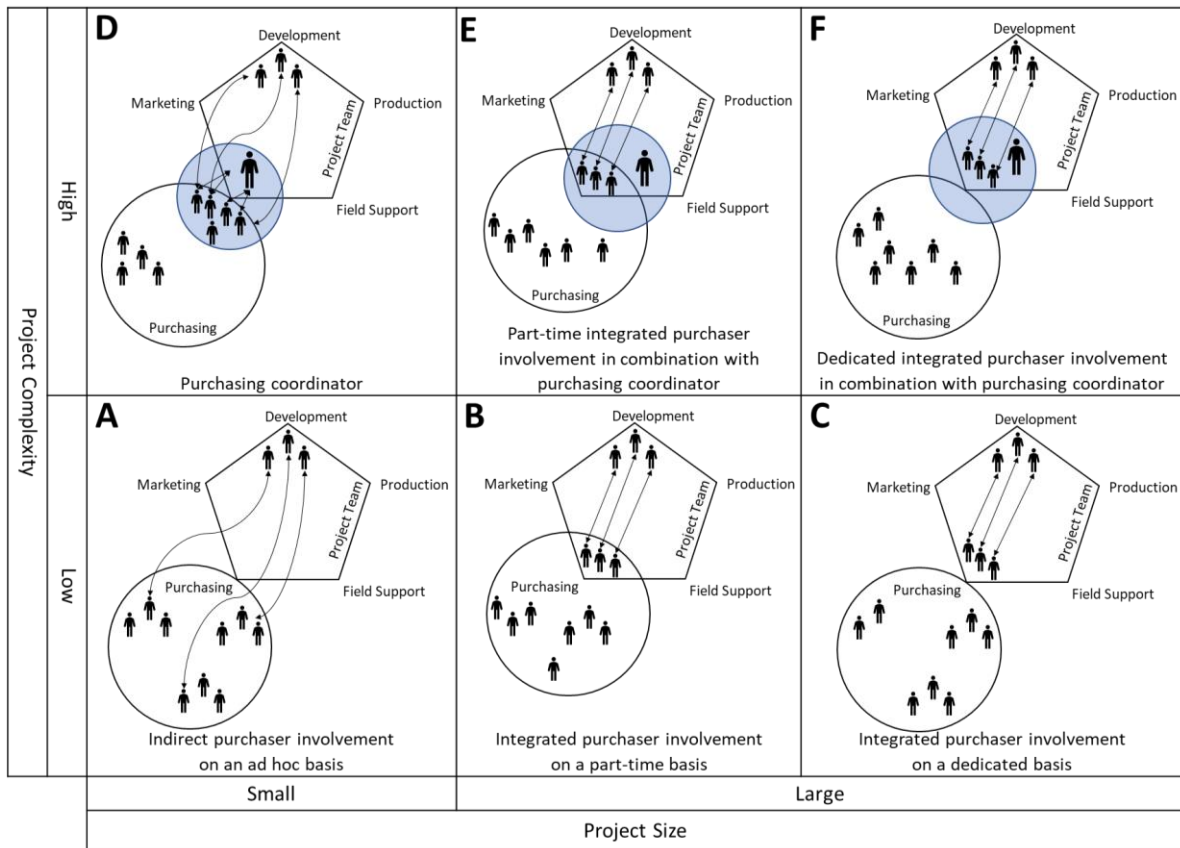


Figure 10: Configuration of purchasing involvement in NPD projects (van Ditshuizen, 2018)

Lakemond et al. (2001) conclude that operational purchasers might not always have time to devote to developmental projects. Hence, one proposal suggests creating a separate purchasing unit focusing on NPD activities. Some companies relate to this activity as purchasing engineer or innovative sourcing engineer. This seems to be in line with the suggestion of Luzzini et al. (2015) to account for conflicting objectives. Likewise, Schiele (2010) suggests implementing an advanced sourcing department as an extra organizational unit, in addition to the life-cycle sourcing team. This situation might be the opposite for start-ups, depending on the phase they are in. Start-ups initially only have procurement agents for the NPD process, after which the life-cycle sourcing team gradually emerges.

### **Relationship Level**

The relationship level relates to formal (controlled by contracts) and informal (controlled by relational factors) governances and their effect on buyer-supplier knowledge transfer (van Weele, 2018a). De Vries, Scheepers, van Weele, and van der Valk (2014) distinguished between exploitative (used for improving existing products) and exploratory (used for creating new products) knowledge sharing. First, the results of their study showed that contracts led to a higher level of knowledge sharing, as specifications provide a frame of reference, making partners share information. De Vries et al. also found a negative effect between contractual incentives and exploratory knowledge. While contractual incentives can be valuable for exploitative knowledge, they force a supplier to stay within the lines and focus on short-term objectives, thus limiting exploratory knowledge transfer. Third, relationship factors were found to be positively related to both forms of knowledge sharing. A similar effect was found by Sjoerdsma and van Weele (2015), who studied the effect of relationship constructs and thought relationship quality on knowledge sharing. Their findings suggest that constructs at the individual level, such as trust and communication, have a greater impact on the quality of the relationship than constructs at the organizational level, such as satisfaction. The authors conclude that firms should actively manage supplier relationships in order to involve suppliers in their innovation process successfully. Therefore, firms should not only focus on formal but also on informal governance (Sjoerdsma & van Weele, 2015). Van Weele (2018a) advise contractors to decide on the level of formality of the contract and focus on the quality of the relationship. Ragatz et al. (2003b) identified seven relationship constructs as success factors for integrating suppliers into NPD, including trust. The relationship level is an important enabler of ESI. For new ventures, this means they have a choice to incorporate relational focus in their culture or strategy, as they have to build a supply base from the ground up.

### **Individual Level**

The last level, individual, addresses a challenge of human interaction. Namely, how supplier engineers can be motivated to share knowledge (van Weele, 2018a). Such a challenge arises when a supplier's organization has concerns about revealing proprietary information or technologies (Ragatz et al., 2003b). Van Weele (2018a) concluded that coordination in development projects influences engineers' motivation to share knowledge. In the case of highly formal coordination, knowledge was only shared when it was driven by reward (fairness). Instead, in cases of less formal coordination, knowledge was shared driven by interest (ethic) or reward. Therefore, managers should consider instructing employees based on either informal (trust) or formal (strict guidelines) coordination, but not both. The benefits of the supplier being involved should be emphasized by the manager when formal coordination is chosen. Furthermore, onboarding practices should be applied by the manager in the case of informal coordination (van Weele, 2018a).

### **Conclusion from Knowledge Sharing in ESI**

In summary, organizing the procurement functions in such a way that it can enable supplier involvement requires a variety of constructs at different levels. First, a good fit with the overall business objectives should be established. Second, it is recommended to create a specific function within procurement to address NPD and resolve conflicting objectives. Third, it became clear that knowledge sharing involves human interaction, which is guided by formal and informal governance. Both mechanisms are important to ensuring people share sensitive information. Though all solutions are valuable, van Weele (2018a) suggests starting with the human side of the cooperation rather than involving all of the structures as, besides the effort, they only provide limited control. Furthermore, van Weele (2018) emphasizes that strategic, operational, and collaborative management processes must be in place in order to build trust and benefit from supplier involvement.

## 2.6 Supplier Qualification and Selection

This section addresses the sourcing phase of the cyclical purchase process. Sourcing, an extension of the strategy phase, includes specification, selection, and contracting of suppliers, and is recognized as perhaps the most crucial activity for organizations (Monczka et al., 2009). Likewise, the selection of the right partner was a recurring subject in previous articles discussing ESI. Mirzaei (2014a) underscored the importance of supplier selection for NPD based on interrelating culture and supplier capabilities. The research of Schoenherr and Wagner (2016) focused on 'softer' supplier selection criteria for NPD success. These authors argued that similar business cultures, strategic orientations, behaviors, and mindset are desirable when selecting partners (Schoenherr & Wagner, 2016). Another example for the importance of supplier selection comes from Song and Di Benedetto (2008), who argue that increased qualification of supplier abilities induced greater supplier involvement after selection. Song and Di Benedetto's study was conducted on new ventures, which makes it especially relevant to this research.

Even though research in ESI stresses the importance of supplier selection, it does not provide much insight on how to do so. The literature review of Ho, Xu, and Dey (2010) and the literature review of Weber, Current, and Benton (1991) may provide guidance. First, both Ho et al. (2010) and Weber et al. (1991) state that selection approaches should be able to handle multiple quantitative and qualitative factors. Second, Ho et al. (2010) reviewed over one hundred selection criteria to discover the most popular ones. Their study showed that quality was the most popular criteria, followed by delivery, price/cost, manufacturing capabilities, service, management, technology, research and development, flexibility, reputation, relationship, risk, and environmental aspects.

Moreover, Ho et al. provided related attributes to measure these criteria. This order reveals that the traditional focus on price or cost is no longer the most widely adopted method. Selection on price alone cannot guarantee that the most optimal supplier will be chosen, especially not from a customer-oriented (quality, delivery, and flexibility) point of view. Finally, Ho et al. (2010) emphasize that business priorities and strategies mostly affect the weighting of supplier selection criteria. Similar results were found in a study by Weber et al. (1991), which implies that not much has changed during the period between 1991 and 2010. However, it is striking that 'softer' criteria, such as cultural alignment proposed by Wagner (2016), were not mentioned by either Ho et al. (2010) or Weber et al. (1991).

Another observation regarding supplier selection was made by de Boer, Labro, and Morlacchi (2001). They note that most of the attention is directed toward the 'choice phase' of supplier selection. This phase is the last phase in which the supplier is actually being chosen. However, this phase can only be properly executed if previous steps are of equal quality (De Boer, L., Labro, E. e Morlacchi, 2001). This refers to steps of the cyclical model, such as strategy, specification, identification of the potential supplier, and others (van Weele, 2014).

Given these points, it is evident that supplier selection is a critical step in the cyclical model. Selection criteria and methods might differ based on a firm's strategic objective. Nevertheless, considering the cost alone seems too short-sighted. Rather, companies should use quality, delivery, and cultural criteria, weighted against each other, with groundwork from prior stages, as this induces greater supplier involvement, to guide supplier selection.

## 2.7 Implications for Start-ups

Several challenges and statements throughout this study have been discussed for both start-ups and PSM. This section links some of these aspects together. The central question is to determine why something would or would not work for a start-up if it is implied by procurement literature. The argumentation is based on the fact that new ventures are characterized by small firm size, lack of resources and information, and limited connectedness to their network (Battistella et al., 2017).

The spend analysis is one of the first aspects mentioned by the cyclical purchase model. This and other analyses for that matter, might be challenging to perform, as start-ups do not process the necessary information to do so. Start-ups should acquire information based on their first production batches, concepts, request for information, or estimates. The accuracy of this data should be considered, as this could, to a large extent, influence decisions. This does not only apply for an initial analysis but also for models such as the KPM.

Another example is the make-or-buy decision that also for a large extent relies on information. In fact, unknown information leads to uncertainty, which then causes market failure according to TCE. Thus, TCE implies that hierarchical governance is preferable in such situations. However, start-ups are characterized by uncertainty, which does not mean that start-ups should produce all items in-house. A start-up should consider a broader view of possible partnerships, resources, and capabilities. This broader view is in line with other theories and practices (Geyskens et al., 2006; Song, Podoyntsyna, Bij, & Halman, 2008).

A third aspect is the fit between the two parties: the buyer and the seller. Unless the start-ups do business with other new firms, they will almost always be in a disadvantageous power dynamic with larger firms. Being the dependent party in a relationship comes with consequences. This again stresses the importance of qualifying and selecting the right supplier. Moreover, it requires a relationship that is built on trust, a construct that was addressed in most of the academic papers. Building trust and finding the right fit could be the main obstacle for new ventures, as they do not have any references of being a good partner, do not have the network with which to connect, and have not the financial resources. New ventures should find other creative approaches to appeal to established firms.

Most other challenges appear to be similar between start-ups and established firms. For instance, knowledge-sharing and human interaction are relevant to all firms, regardless of size. The only difference might be that start-ups face these challenges for the first time, which means that they do not yet possess the experience to deal with specific problems. An experienced procurement officer could provide this knowledge if the budget allows for it.

Most procurement theories and models could serve as valuable guidelines, even though they are primarily focused on established firms. However, the unique characteristics of a new venture (i.e. firm size, lack of resources, and limited connectedness) must be considered when using these research frameworks.

## 2.8 Conclusion from Literature

Several topics are included in this review to determine how start-ups could build a supply chain. This section defines the research model that can be derived from this supply chain topics. The review initially prioritized the make-or-buy decision, supplier involvement, and supplier selection. However, relationship management was added as fourth construct since the review indicated its relevance and the potential for new ventures. Moreover, literature has demonstrated that procurement is embedded in a business context that could not be omitted. Business context is not a construct on its own; instead it influences all topics.

First, transaction cost economics were found to be a useful framework to guide the make-or-buy decision because they assess a strong set of transaction aspects. Nevertheless, a start-up should consider a broader view of potential partnership, resources, and capabilities. The resource-based view of the firm can provide an expanded view as a complementary framework. Moreover, the company should consider if its competences are strategically important and can be performed on a competitive level relative to external providers.

Second, a new venture should consider the degree of supplier involvement for the outsourced items. Supplier involvement in the NPD process has the potential to improve the performance of start-ups if managerial challenges are overcome. The literature addresses several of these challenges. One fundamental question is when to involve suppliers. Timing should be based on the responsibility and capability of the vendor. Another vital aspect is organizing the procurement department in such a way that it can support NPD. This involves being capable of managing human interaction, which is a complex aspect. Essentially, this aspect is about building trust between suppliers and buyers. Strategic, operational, and collaborative processes must be in place to build trust and benefit from supplier involvement.

Third, literature has argued that successful involvement of suppliers is impossible if the right supplier is not selected. Thus, supplier selection is a critical step in building a supply chain. While strategic objectives may influence selection criteria, a focus on the cost alone seems to be too short-sighted. Instead, start-ups should use quality, delivery, and cultural criteria that are weighted against each other and based on a secure foundation of prior stages to guide supplier selection.

Fourth, relationship management was not selected as primary construct in advance. However, during the research, it became apparent that trust and relationship management are important factors in all the company's aspects if it is to benefit from purchasing and supply chain management. Therefore, relationship management is added to the research framework because this will enhance supplier involvement, which ultimately contributes the performance of new ventures. It should be noted that the mediation or moderating effects of this construct are not displayed within the framework. Although it is likely that these effects will exist alongside a direct relationship, it could not be measured due to the nature of this research. Hence, the research chooses a simplistic visualization.

These four principles are embedded in an environment. Almost all authors have argued that the right measures depend on a variety of case-specific aspect. For instance, a corporate multinational will have a perspective on a €10.000 risk that is different from that of a recently established firm. Our research framework, therefore, refers to these internal (e.g. business strategy) and external factors (e.g. industry) to be the business context in which the firm operates. This context is not a construct of the framework but should be considered by the start-up when developing a supply chain. The business strategy and a spend analysis are often proposed by academics as fundamental for mapping this context.

Start-ups should consider four main constructs when building a supply chain. First, the make-or-buy decisions should be resolved, based on broad view on transaction costs, the firm’s capabilities, and the strategic importance of competences. Second, the firm should involve suppliers in a timely manner while considering their responsibility, value potential, and development risk. In this process, it is critical to select the right supplier based upon quality, delivery, and cultural selection criteria; these criteria should be weighed against each other and based on a secure foundation of preceding stages. Fourth, these aspects require trust between firm and supplier, which means that relationship management must be in place to facilitate the prior constructs. Finally, these four constructs operate in a business context that should be considered by new ventures before any measures are chosen.

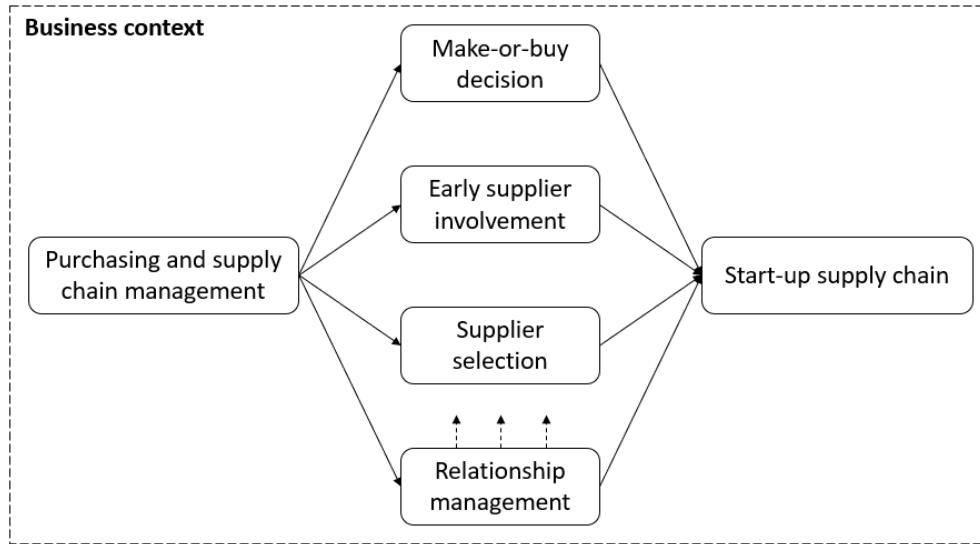


Figure 11: Research framework

The research framework indicates that a start-up should first understand the environment in which it operates before it can select the appropriate measures for building a supply chain. For that reason, the next chapter will start by analyzing the business context of PAL-V because a solution for the construct cannot be designed without the knowledge from that analysis. A solution design will be proposed in chapter 4 “Solution Design and Implementation”.

### 3 Analyzing the Business Context to Facilitate the Solution Design

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The systematic literature review serves the first purpose of the analysis and diagnostic phase by defining a preliminary conceptual research model. This chapter will serve the second purpose of the analysis phase by studying the business context in which PAL-V operates. Literature has demonstrated that procurement should not operate in isolation of the business but rather should be aligned with the overall strategy (Batenburg & Versendaal, 2006; Monczka et al., 2009; Virolainen, 1998). Hence, this chapter first maps PAL-V's business strategy and sales forecast. In addition, the literature has advised to perform a spend analysis to gather an understanding of the supply base, product, and cost price structure (van Weele, 2014). However, a general approach for this analysis has not been provided by academics. That is why the spend analysis draws on the principles of CRISP-DM as inspiration. Finally, a focus group was conducted with a double purpose: to validate the research model and discuss potential implications for the solution design. The focus group does not map the business context but it does form a bridge between the research model, business context, and solution design. Therefore, the outcomes of the meeting are discussed last.

#### 3.1 Mapping the Business Strategy and Sales Forecast

PAL-V is raising funding to start industrialization after commercial launch. Hence, the strategy of PAL-V is well documented because these funding forms are presented to potential investors. This documentation was read and discussed with the management, after which the strategy was mapped in BMC. This model, which has been introduced by Osterwalder, Pigneur, and Clark (2010), is considered to be a valuable tool due to its simplicity and visual representation (Ching & Fauvel, 2013). The model was reviewed and approved by management after it was constructed. Extra attention was paid to the core activities, competences, and resources of PAL-V since these aspects form the backbone of the make-or-buy decision.

Although the BMC has a broad perspective, it does not include all strategic aspects of PAL-V. Therefore, the research drew from the sales forecast because the order quantity of items significantly influence the cost of products. Moreover, the capacity of suppliers should match PAL-V's future ramp-up. The sales forecast was composed in the same manner as the BMC, except that more departments such as sales and engineering were involved.

The results of the meetings could not be incorporated into this report due to the confidential nature of the information, please refer to *Appendix III.I.* for the BMC. The BMC demonstrated that PAL-V is clearly a technologically driven company which focuses mainly on R&D activities because it is important to obtain a type approval for the vehicle at this stage. Currently, the firm is setting up a production organization and a global sales network. PAL-V's most important resources are financial and knowledge assets. Furthermore, it has become evident that PAL-V is internally focused i.e. they want to keep activities in-house. This can partly be explained by PAL-V not being able to connect to partners in the past as suppliers perceived PAL-V to be too risky. Another explanation might be the firm's R&D nature. The phrase "*not invented here syndrome*" comes to mind. Finally, it has become apparent that PAL-V is fine tuning its identity and thus cannot always answer strategic questions.

The sales forecast in *Appendix III.II.*, indicates a steep ramp-up after the second year of production, which might be challenging for potential vendors. These suppliers must be capable of and willing to grow with PAL-V. Moreover, the forecast enables a committed volume could to be communicated to suppliers. Previously, suppliers and employees received different order quantities over time, which lead to confusion.

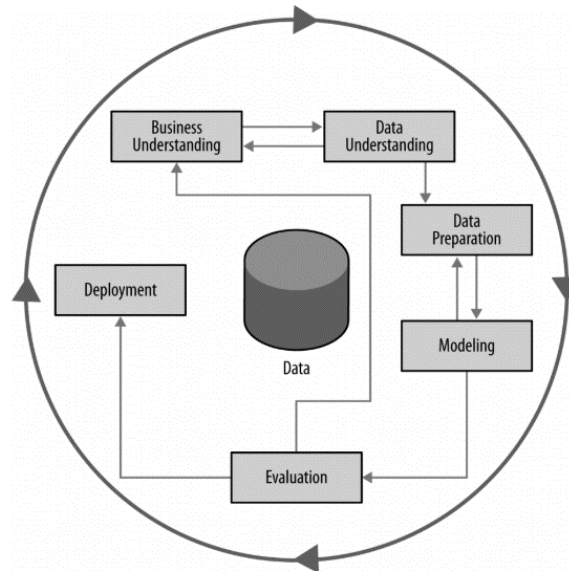
PAL-V's strategy is technologically driven with a strong preference to keep activities in house. The firm possesses the necessary knowledge assets to do so but has not considered the steep ramp-up after second year of production. Hence, PAL-V should consider finding partners who are capable of and willing to grow with PAL-V's future order quantity. This consideration will be continued at the make-or-buy decision.

## 3.2 The Spend Analysis

The spend analysis is the second aspect of the business context. The objective of this analysis is to gain an understanding of cost and product structure, supply base, and NRE. The results will present these three aspects consecutively, but the methodology for the analysis is provided first.

### 3.2.1 Methodology Spend Analysis

The methodology for the spend analysis was inspired by the CRISP-DM, which is illustrated in *Figure 12*. Although this method is normally used for more complex and extensive large data mining projects, it is a well-understood process that allows for consistency, repeatability, and objectivity (Provost & Fawcett, 2013). The figure illustrates how the method follows an iterative nature.



*Figure 12: Cross Industry Standard Process for Data Mining (Provost & Fawcett, 2013)*

#### Business Context

The business problem must first be understood before an analysis can start. The problem statement has been defined, but other questions for the analysis still remain: for example, how reliable the current cost estimation of the vehicle is, or what the spend analysis should reveal. Hence, the focal firm's supply chain must be understood instead of the thesis' problem statement.

#### Data Understanding

The second phase consists of gathering and understanding the data so that it can be matched to the business problem. Moreover, the data's strength and limitations must be accessed (Provost & Fawcett, 2013). Data was gathered from three sources: metadata from the ERP system of TV1, corporate documents, and engineering and procurement insight. Currently, the data will not generate a 100% accurate model, which is not a problem in this phase. The most important achievement is for a first analysis to be generated as guidance and exploration for supply chain development. The model should be revised once more data is available.

#### Data Preparation

Different models require different data representation forms. Thus, data must be prepared for instance by converting it to a tabular format and removing or inferring missing values (Provost & Fawcett, 2013). The latter aspect is especially important because no general method could be applied. Each missing value was independently dealt with, while this approach was time-consuming, it was also the most accurate.



Furthermore, data was converted to Excel, where each row represented a module (i.e., assembly) or item, and all columns represented an attribute such as part classification, commodity group, supplier, price, and so on.

### Modeling

The research diverges from the CRISP-DM in that no data mining techniques were used. The calculations in the model are fairly basic and can be performed with standard Excel functions: counting the numbers per classification, adding the cost, finding the amount per category, and so on.

### Evaluation and Deployment

The outcome of the spend analysis was evaluated through discussion with the procurement department and compared to previous estimates. Both discussion and comparison indicated that the results were sufficiently accurate and thoroughgoing. The cost calculation could also be reused, but it would be more logical to adapt the ERP functionality rather than use manual calculations. This functionality was not and could not be made in operating order during the thesis because too much data was missing in the system. The models and results were deployed directly as these provide the basis for the solution design.

### 3.2.2 Spend Analysis Results

The spend analysis resulted in an in-depth understanding of the cost and product structure, NRE, and supply base. The following section will present these parts consecutively. Note that due to the confidentiality of the data, only the four largest of the nine commodities are included into the results. The other categories are referred to as “miscellaneous”. These four categories will hereafter form the scope of the thesis. Please refer to *Appendix IV.III.* for a complete overview.

*Table 4: Product structure PAL-V Liberty*

#	Generic	Analysis	Expected	Classification / Supplier	Analysis	Expected
1	Modules (800)	103	100-105	Class 1	8 0.5%	40 2.2%
2	Assemblies (400)	36	50	Class 2	187 10.9%	520 28.9%
3	Items / Vehicle	4912	5000-5500	Class 3	241 14.1%	450 25.0%
4	Unique items	1714	1800-2000	Class not applicable (NA)	667 38.9%	790 43.9%
5	BOM rows	2129	2200-2500	Class unknown	611 35.6%	
6				Price known	856 49.9%	1800 100%
7				Price unknow <sup>1</sup>	858 51.1%	
8				Supplier known	888 51.2%	1800 100%
9				Supplier unknow <sup>1</sup>	826 49.8%	

*Note 1: Price or supplier were classified as unknown when there was no quotation available i.e. a committed price of the supplier was missing. Nevertheless, the majority of unknown allocated prices were based on cost indications from the market*

First, *Table 4* summarizes the generic product structure of the vehicle. The results are presented on the left side of the table, and an estimate is provided on the right because the design is not complete. The vehicle is expected to have 1800 to 2000 unique parts. The supplier is unknown for about half of these parts (49.8% of 1714) due to the design stage. This means that the procurement department will face a significant workload of ordering parts for test vehicle 2 (TV2), which is the next deadline. Moreover, the absence of data made it hard to accurately predict the cost price of the vehicle. The analysis indicated an even higher cost price than previously expected. However, a worst-case-scenario was assumed when cost were missing whereas the previous estimates took an optimistic view. For instance, the previous analysis assumed cost would decline with a factor when production numbers would increase. It was concluded that estimates provide an approximated cost price before and after the ramp-up. Both validate the problem statement presented by PAL-V.

Furthermore, *Table 4* illustrates that items are classified into four classes. Higher classes occur less often than lower classes, while a significant share (35.8%) is still unknown. Classification ensures the appropriated level of control throughout design, procurement, manufacturing, and service life (Stekelenburg, 2017). This method is imposed by the European Aviation Safety Agency (EASA, 2012). Classes are based on the severity of failure: a failure of a class 1 part could lead to catastrophic effects on the aircraft. Logically, the suppliers should meet high quality standards. On the other hand, failure of class 3 parts could lead to minor or no effects on safety. Hence, less strict controls are justified. Classification of normalized parts, specified by other manufactures for various customers, is not applicable since several PAL-V installations are possible. Although there are some logical relations between parts and requirements, no universal rules could be defined (Stekelenburg, 2017). Nevertheless, classes provide guidance on the part level for supply chain development.

Second, *Table 5* indicates the cost structure as well as the division of parts and suppliers among the commodities. Clearly, attributes are not evenly distributed among all categories. Composites and major components account for half (45.8%) of the cost, while these groups represent only 4.1% of the parts and 4.8% of the suppliers. Standard parts, on the other hand, are responsible for 6.5% of the cost while its share in parts and suppliers is around 50%. These result suggest a Pareto distribution which can be seen in *Appendix IV.II.,.* This means that 20% of the parts determine over 80% of the vehicle’s cost price. The same rule applies for suppliers, which suggests that these parts and their respective suppliers are an priority based on cost alone. Although aspects other than cost are not considered, commodity value is an important input for further analysis such as the KPM.

*Table 5: Commodity parts, cost, and supplier structure PAL-V Liberty*

#	Commodity	Parts		Cost <sup>1</sup>		Suppliers	
1	Composites	40	3.5%	-	28.7%	2	1.9%
2	Machining	229	19.9%	-	26.5%	27	25.7%
3	Major Components	7	0.6%	-	17.1%	3	2.9%
4	Standard parts	647	56.4%	-	6.5%	52	49.5%
5	Miscellaneous	225	19.6%	-	21.1%	21	20.0%
	<b>Total</b>	<b>1148<sup>2</sup></b>	<b>100%</b>	-	<b>100%</b>	<b>105</b>	<b>100%</b>

*Note 1: Cost are confidential, please refer to Appendix IV.I.*

*Note 2: Total number of parts is not equal to total number of unique parts because some price estimates combined multiple parts in one. Essentially, the costs were allocated to one item in the analysis.*

Third, not only components but also NRE were identified. If present, these expenses significantly determine the total cost of an item. Non-recurring expenses can also be critical for the lead time. For example, production of the major composite mold could take up to 3 months. An overview of expected NRE can be found in *Appendix IV.III.*

Fourth, *Figure 13* depicts the number of suppliers and expenditures per country. As can be seen, PAL-V has been mainly sourcing in Europe, and the majority is coming from the Netherlands. However, PAL-V has recently started to approach Eastern European countries and China for some of its items. The first quotations indicate that these countries provide opportunities for cost reduction. It should be further noted that Austria and Spain only have a relatively high spend rate because the most expensive items, such as engines, come from those countries.

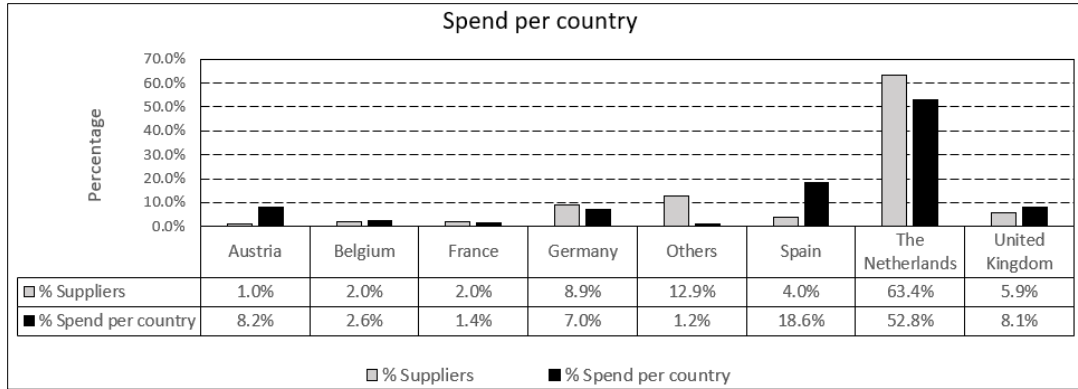


Figure 13: Spend and supplier per country

The spend analysis proved to be a valuable start point because it validated the problem statement presented by PAL-V, and new insights were discovered that could guide further supply chain development. First, the procurement department should account for the upcoming engineering orders. Second, part classification could help to justify applicable control at the component and category level. Third, cost and lead time of NRE might be critical and therefore should be considered by the procurement department. Finally, PAL-V currently sources predominantly in Western Europe but the first steps towards other countries have been made. Further investigation of the potential of global sourcing is needed.

### 3.3 The Focus Group of PSM Experts

The third and last part of the analysis phase is the focus group with PSM experts. This interactive meeting bridges the research framework, business context, and solution design. The idea behind the meeting was to simultaneously validate the research model and form possible implications for the solution design that are applicable in the business context of PAL-V. Participants have a fresh outside view of challenges in the business context. The meeting also allows for time efficiency which is important because participants' time is valuable. Five CPO's of Dutch multinationals in high tech and aerospace industries were invited. ASML, VDL ETG, and Fokker GKN Aerospace participated (3/5) as did PAL-V's CEO, R&D manager, and strategic Buyer of PAL-V. The meeting was co-supervised by purchasing and supply chain professor van Weele of the Technical University of Eindhoven. The panel, eight in total, gathered at PAL-V for a presentation about the current supply chain and business context. An extensive discussion on five predefined statements followed. These statements (*Table 6*) were derived from both the research model and current supply challenges. Relationship management was not added as a statement but was incorporated during all discussions.

Table 6: Focus group discussion statements

Construct	Discussion statements
Make-or-buy	1. <b>Make-or-buy:</b> How should PAL-V approach the make-or-buy decision?
Supplier involvement	2. <b>Power imbalance:</b> How should PAL-V enable suppliers to be involved, especially in cost reduction? 3. <b>Global sourcing:</b> Which parts would be most suitable for global sourcing? Which aspects should PAL-V consider when sourcing globally? 4. <b>Learning curve:</b> How could PAL-V achieve continuous improvement with its suppliers?
Supplier selection	5. <b>Supplier selection:</b> Which are the most important risk factors to consider in supplier selection?

The six most important observations of the meeting are summarized below in the same order as above. Notes of the meeting can be found in *Appendix V*. The participants understood the business context of a new venture and generally shared the same view towards the supply challenges faced by PAL-V.

The first theme was the make-or-buy decision. Everyone agreed that this decision is never financial. Rather, it should be purely based on protecting IP and focusing the firm's core business: the choice is driven by technological, strategic, and competence-based concerns. The corresponding view of the group is similar to that of the research model. For PAL-V this view would imply a high-level assembly or even no production at all because its competences are within R&D. The panel argued that PAL-V should reconsider their make-or-buy decision for some of its products (Bogers et al., 2018).

The second construct was supplier involvement for which three statements were conceived. All participants fully agreed that suppliers could play a significant role in the existence of new ventures. The first problem, however, is that PAL-V is often the less dominant party relative to its supplier, which creates a power imbalance. This problem can be solved by appealing to the firm. The experts stated that PAL-V is interesting for two reasons. First, it has high growth potential, which is compelling to the smaller firms as they can lift on PAL-V's success. Second, PAL-V is seen as innovative ground-breaking product which therefore has marketing value (Bogers et al., 2018). Van Spall (2018) concluded, "*Why sponsor Formula 1 when you can supply to a flying car*". In addition, he stated that it helps to have mid-term leverage which can be achieved by "*dual competences, single sourcing*" (Van Spall, 2018). This means a partner is the only supplier that makes a given product but the capability needed for production is provided by more than one vendor in the supply base.

The third statement discusses the potential of global sourcing. This topic was outside the scope of the literature research. Nevertheless, it becomes relevant when a firm considers involving suppliers from outside the country, which is currently the case for PAL-V. The experts strongly recommended local sourcing for critical items at this stage because PAL-V needs to intensively communicate with its suppliers. Less critical items might be sourced more globally if a mature supplier is selected. Since PAL-V's volume is relatively low, it is anticipated that Eastern European and Southern European companies may provide an opportunity for cost reduction if logistics were to become problematic for non-European countries. However, the panel strongly discouraged approaching some countries, including China, due to cultural differences (Bogers et al., 2018).

Fourth, the panel discussed how a learning curve could be achieved. This statement was added because PAL-V wishes to reduce the cost price over time with its suppliers. Companies with a continuous improvement culture are more likely to accomplish cost reductions. Moreover, the panel stated that suppliers should be willing to work with open cost calculations. Such quotes enable the firm to gain insight about cost drivers and potential cost savings. Open calculations only work if a relationship is built on trust (Bogers et al., 2018).

The fifth statement was supplier selection. Again, the panel was fully aligned and argued that supplier DNA should form the basis for this decision. Supplier DNA refers to the size, culture, and objective (mission or vision) of a company. A suitable fit for PAL-V would be a family owned company over a venture capitalist one; with a similar business size; willing to grow and invest; and focusing on innovation (Bogers et al., 2018). However, PAL-V should not become the "hobby" of someone, for instance a salesperson, within a vendor. A person can leave, DNA cannot (Jagtenberg, 2018).

Finally, relationship management was not a standalone topic but was discussed through the meeting. Relationships are essential and must be built from the ground-up, which is especially challenging. Building

a relationship takes time and trust should not be damaged along the way. Hence, it is necessary to have communication that is open, honest, and frequent (Bogers et al., 2018).

Generic problems and strategic issues were also discussed beside. For instance, the panel questioned why cost was used as an argument and not quality. This led to some new input for management meetings and reconsiderations on the strategic level. The outcomes of this input was included in the BMC.

The conclusions that can be drawn from the meeting are in line with those of the research model. Both argue that competences and strategies should guide the make-or-buy decision. Nevertheless, the PSM specialists stated that cost should never be a leading consideration. This statement implies that TCE is less relevant than has been suggested by the literature. Furthermore, the panel fully agreed about the essence of supplier involvement and relationship management. They concluded that PAL-V should use its appeal to improve both constructs. Global sourcing was not included in the literature review. While global sourcing could provide opportunities, it should be carefully considered. Finally, the group stressed the importance of supplier selection and vendors' DNA, which is in line with the reasoning of Song and Di Benedetto (2008) and Schoenherr and Wagner (2016), among others.

### **3.4 Conclusion from Business Context to Facilitate Solution Design**

The objective of this chapter was to outline the business context in which PAL-V operates to facilitate the solution design of the next section. The context was divided in a business strategy and sales forecast as well as a spend analysis. Next, a focus group was conducted to bring the research model, context, and solution together. The business strategy determined that PAL-V is a technologically driven company that focuses mainly on R&D activities. Furthermore, PAL-V is setting up a production organization for which the firm desires to keep activities in-house. In contrast, the focus group suggested a more external focus based on the capabilities and strategic objectives of PAL-V. This suggestion would support the steep ramp-up after the second year of production that has been projected by the sales forecast.

Moreover, both the sales forecast and the spend analysis demonstrate a significant workload for the procurement department. The expected demand should be met but suppliers must also be selected for over half of the items. The procurement department should account for this upcoming workload.

The spend analysis further indicated that partial calcification could help to justify applicable control at the component and category level. It is important to realize that NRE should be considered as well because cost and lead time of these expenses might be more critical than the items themselves. Finally, the supply base was predominantly sourced in Western Europe, but the first steps towards other countries have been made. The focus group believes that global sourcing should be carefully considered even though it could provide opportunities for less critical items.

In addition, the expert panel argued that PAL-V should exploit its reputation and marketing appeal to improve supplier involvement and relationship management. Communication that is open, honest, and frequent is necessary to support the contractual relationship. Finally, the experts emphasized the importance of vendor DNA in guiding supplier selection. The proposed implications were in line with those of the literature, thereby validating the research model. Moreover, additional implications were suggested, which will be considered in the solution design.

## 4 Solution Design and Implementation

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This chapter is directed to the fourth phase of the knowledge-generating process, namely solution design and implementation. The solution continues with the four constructs of the research model: the make-or-buy decision, supplier involvement, supplier selection, and relationship management. The design methodology, implications for PAL-V, and a conclusion will be presented for each construct. Next, the chapter presents a supply chain strategy, implementation, and a revised research model. Finally, the chapter ends with a conclusion of the overall solution design.

### 4.1 Make-or-buy Analysis and Decision

The starting point of building a supply chain is the decision over whether products should be produced in-house or outsourced in the market. PAL-V already had a policy in place before the beginning of this research. This policy has stated that all items are bought on the lowest BOM level possible and are assembled in-house to reduce costs (suppliers take profit), minimize the coordination effort (multiple supply chain layers), secure quality (aerospace certification), and ensure time to market (Rietdijk, 2016). The main reasoning behind this policy was that PAL-V, as a responsible design organization, was developing items at this low level. It would take extra effort to involve partners who assembled modules. At that time, this argumentation was valid while now this policy seems to be the opposite of the suggestions by the PSM panel and the first design principle. Hence, the research identified four activities for which the make-or-buy decision was reconsidered: vehicle assembly, welding, rotor and propeller blade production, and painting. The first three are currently preformed in-house, while the latter is outsourced. Painting was never considered to be part of PAL-V's production process but could significantly influence logistics and facility layouts. A paint shop was consulted for expert knowledge on this subject.

A complete summary of the make-or-buy analyses and outcome per activity can be found in *Appendix VI*. The summary involved an analysis of resources, capability, and capacity; a cost estimation of in-house production compared to outsourcing; evaluation of pros, cons, and risks; important strategic considerations; and possible scenarios. The analysis drew on all aspects that have been suggested by the literature. As expected, the strategic and capability-related aspects proved to be the most useful guidance. On the other hand, competitiveness relative to suppliers was hard to evaluate because activities have not been performed in-house. Moreover, transaction costs could not be omitted but were never decisive, which seems to be in line with the suggestions provided at the focus group (Bogers et al., 2018).

Welding is an illustrative example of the decision-making process. Initially, there were two main reasons why welding was kept in-house. First, a quotation of a potential supplier was assumed to be too high. Second, certification requirements forced PAL-V to start the welding process in-house to gain design feedback. The design engineers who were responsible for main welding activities were also involved in the decision making. They provided information and their view of possible scenarios. The analysis indicated that capacity would become an issue during the ramp-up phase. Extension of production might not be possible due to limited available resources, which mainly come in the form of certified welders. Since vendors already possess these resources, the decision was made to start a sourcing procedure. The vendor could gradually take over welding activities during a joint development process to secure quality.

A similar outcome for rotor blade production was reached while the other activities remained unchanged. Clearly, the shift towards outsourcing has a significant impact on internal production processes as well as the supply chain of PAL-V. Partners must be found with whom a relationship has to be built. In addition, the old policy was substituted for a new strategy to guide future make-or-buy decisions. This guideline is included in the supply chain strategy of *Paragraph 4.5*.

## 4.2 Supplier Involvement

The second construct of the research framework is supplier involvement. This is a broad construct that can be projected on all aspects of the supply chain. However, it is too late for PAL-V to discuss “early” involvement because the design is almost finalized. Nevertheless, involvement of suppliers could still be of significant value in this phase. Hence, the practical application of supplier involvement was divided into two elements: a commodity strategy and supply chain planning. The commodity strategy concerns whether the supply base should be reduced, what type of relationship should be pursued, and whether local presence is favored, among others (van Weele, 2018c). Thus, the strategy guides appropriate measures on the supplier and component level. These measures are translated into a plan to ensure alignment between the engineering and procurement department.

### 4.2.1 The Commodity Strategy

The commodity strategy for PAL-V was developed in two stages. A Kraljic portfolio analysis was conducted in the first stage. This method is a methodology that is widely recognized by academics and practitioners for strategic guidance (Montgomery et al., 2017). However, literature has not defined a measurement scale. Therefore, a model of Accent Inkoop Advies and Purfacts was adopted (Holman & Corts, 2011). The authors defined four measurement dimensions for supply risk, which should be scored on a 0 to 3 scale. As Table 7 indicates, 0 refers to the lowest risk while 3 refers to the highest possible risk. Each commodity was scored together with the procurement department. This led to an overall supply risk score, which is indicated along the vertical axis of KPM. The accompanying supply challenges can be found in *Appendix VIII*. The horizontal axis displays the value potential per commodity, which was covered in the spend analysis of *Paragraph 3.2*.

Table 7: KPM risk dimensions and scoring

#	Dimension	Description	Score: 0,1,2,3
1	Scarcity	Degree to which alternative supplier are available	Many - None
2	Switching of supplier	Time and cost involved with switching to alternative suppliers	None - Long/high
3	Technology	Speed of technological development	None - Fast
4	Supply disruption	Impact of disruption on primary processes	None - Major

The results of KPM were discussed with the procurement department in the second stage to design the commodity strategies. This stage also considered the suppliers’ perspective if (potential) vendors were known, as has suggested by van Weele (2014). The stage also considered the involvement portfolio of Wanstra and Pierick (2000) to broaden the perspective of the KPM. The findings from largest to smallest commodity are presented below, while detailed strategies are included in *Appendix IX*. The 15 strategies were developed on the sub-commodity level because this stage requires precise guidance for PAL-V.

It can be observed from *Figure 14* that the KPM indicates that the commodities are more towards the right side of the quadrants, which illustrates the complexity of the mix. This can partly be explained by the high degree of aerospace-quality requirements and the low standardization of the design. Both cause there to be fewer suppliers or alternatives that are eligible, hence resulting in an increased scarcity. Moreover, multiple components are single-sourced because the supply chain must be built, which results in risk as well.

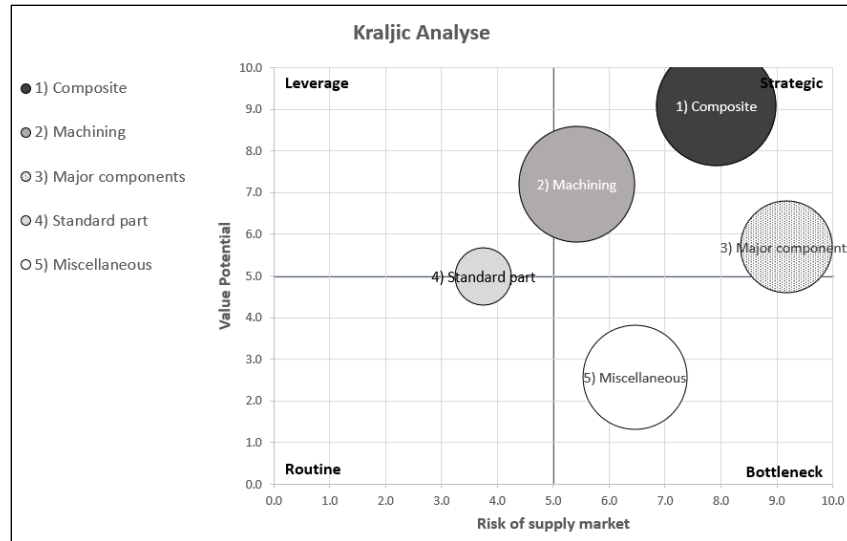


Figure 14: Kraljic portfolio matrix for PAL-V

Composite, which is the largest commodity, is characterized by high value and high supply risk. Reasons for this include labor intensive and complex production processes. These cause different products to require different supplier capabilities even though they are composed of similar materials. Hence, switching would have a significant impact. Other reasons are that the current suppliers are not capable of producing the expected demand, alternative vendors are scarce, and certification requirements are high. These issues explain the position of the commodity in the strategic quadrant, which implies that a strategic partnership would be favored. PAL-V should start an extensive sourcing procedure to expand the longlist of aerospace-approved suppliers. In addition, it is advisable to closely monitor opportunities for joint ventures or strategic alliances with production partners who are willing to cooperate with PAL-V. The partner preferably has a similar culture, size, and is located close by. PAL-V could use its marketing potential to increase the interest of these partners.

Machining, which is the second largest group, forms less risk because there are more alternative suppliers that are easier to switch to. Nevertheless, the commodity is still in the strategic quadrant due to strict aerospace requirements and its impact on primary processes. The relationship with existing vendors should be strengthened, and an extension of the supply base for critical items (i.e. class 1) would be favored. These suppliers are preferably geographical close and aerospace approved. On the other hand, less critical items (i.e., class 2 and 3) do not necessarily require an extension of the supply base. Hence, it would be possible to source more globally and combine packages to increase volume. This would increase the interest of suppliers. Hence, PAL-V should identify appropriated packages per supplier and start negotiation with contracted vendors.

Major components such as power plants are the third largest commodity. These are located at the far-right side of the strategic quadrant because no alternative suppliers exist and switching would have major design consequences. In addition, the gearbox is on the critical path for the next deadline and requires close monitoring. Frequent face-to-face communication on both engineering and management levels should support the development and operational activities. Investment in the relationship to establish a partnership is critical for this commodity.

Fourth, standard parts are the first type of non-strategic commodity that are located at the border of leverage and routine. Normally, there would not be much risk involved with standard parts. However,



standard parts for the aerospace industry require strict controls and cannot be bought anywhere. Further, some automotive suppliers are not willing to supply PAL-V as they have a policy of not delivering to the aerospace industry. In addition, because no single vendor could supply all items, there has been a large supply base of 52 suppliers. PAL-V wishes to reduce the number of suppliers to diminish the overhead cost but is struggling to find a partner. It is recommended that this process be continued, although it is not as critical as the process for other commodities and thus should not be a priority in this stage.

Miscellaneous, the last group, includes six commodities for which an average score was taken to determine its location. The only general statement that can be made is that all items face some challenges, causing a supply risk. However, these challenges are diverse and should be managed in different ways. One potential risk is that challenges are not yet defined and could be forgotten. The proposed strategy is to focus on alignment of the engineering and procurement department to identify more critical items. The next step would be to define actions to reduce risk.

A more partnership-focused strategy applies to the commodities which are further towards the right side of the KPM, such as composites and major components. Geographical proximity and an extension of the supply base are preferred to support communication and reduce risk. Moreover, PAL-V should exploit its appeal to connect vendors because volume alone is not attractive enough for these groups. By contrast, costs are more prevalent for the commodities on the left side of KPM, such as standard parts. In this case, the geographical location is less leading, reducing the supply base is favored, and some leverage can be achieved by combining items into packages.

#### 4.2.2 Supply Chain Planning

The second element is an organizationally broad form of supply chain planning. Previously, the engineering department was in the lead, meaning that they developed according to their own schedule and involved the procurement department only when drawings were completed. Subsequently, suppliers were involved at a late stage of the design process. Engineers had reserved a timeframe for supplier feedback, ordering, and lead time based on estimates or previous RFQs. This way of working had two main consequences. First, the procurement department was unable to foresee the upcoming request of the engineers. Hence, purchasing could not construct their own schedule. Second, suppliers were involved too late, which led to missed deadlines due to redesigns or capacity issues. A joint schedule aims to bridge the gap between engineering and procurement because both would follow the same plan. This ensures that the procurement will be informed about upcoming requests. In addition, the status of engineering and sourcing activities can be discussed and intervened on if needed. Last, a planning enables procurement to better involve suppliers in the development process. Some items require supplier feedback earlier than others.

The planning needed to fit within the existing engineering processes. It was therefore created on module level because this was already used to monitor development activities. The schedule was created in Excel since no other schedule software was available and the MRP functionality of the ERP system is far from operational. The schedule was set towards the next main deadline, namely the production of TV2. Both procurement and engineering provided data for processes and duration. The standard sourcing process [technical specification, supplier (long) list, RFQ, preferred supplier, negotiation round, and contracting (van Nuland, 2016)] was not changed as no problems occurred with it. As can be observed in *Figure 15*, the planning displays an estimated delivery date as well as a last ordering date to identify if the deadline could be met. For instance, rotor flight control would be supplied too late if no actions are taken. The planning was adjusted during the first meetings, after which it remained relatively stable. Now, the planning is a weekly topic in the team lead meeting for the monitoring of development and sourcing activities.

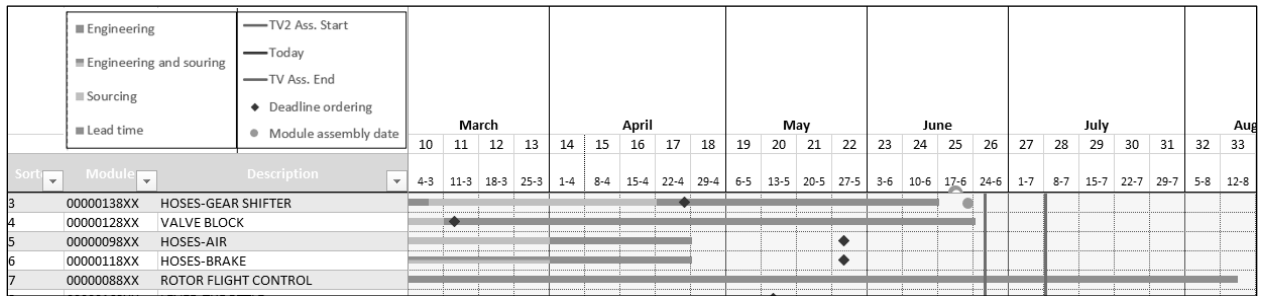


Figure 15: Screenshot of supply chain planning

#### 4.2.3 Conclusion from Supplier Involvement

A commodity strategy and supply chain planning were designed to bring supplier involvement into practice. The strategy guides decisions on the supplier and component level, whereas the planning bridges the gap between the engineering and procurement department. There is an interaction between the two from which priorities emerge. These priorities form the input to manage the procurement department and its activities.

#### 4.3 Supplier Qualification and Selection

Supplier selection, the third construct of the research framework, relates to the fourth design principle. This principle suggested that start-ups should use a balanced set of quality, delivery, and cultural selection criteria. PAL-V's existing model (Weterings, 2016) does not meet these suggestions and therefore needs to be revised. In addition, discussions with the procurement department revealed that the former model was perceived as too complex and time consuming. Logical reasoning was preferred over the model (van Dijk & van der Braak, 2018). Hence, the process was simplified and subdivided into four parts. Design of the process and models followed iterative steps of design and evaluation by the procurement department. The supplier selection and qualification process is visualized in Figure 16. The accompanying models such as the supplier screening table, supplier process scan, and the trade-off tool are presented in Appendix X.

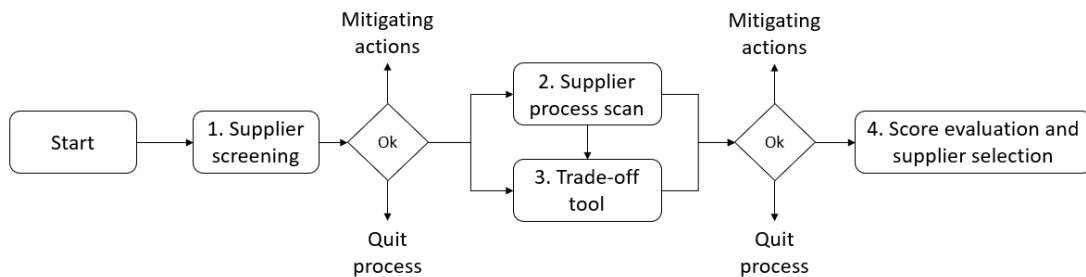


Figure 16: Supplier selection and qualification process

The first part is called the supplier screening (1) which enables the procurement department to quickly scan a potential vendor. This step was added to reduce time. It can be considered to be a checklist of characteristics that either are or are not in place. For instance, the list contains quality standards (ISO9001, AS9100, etc.), processes (product development, manufacturing engineering, etc.), and industries (Aerospace, automotive, etc.) A supplier with AS9100 receives more point than a supplier with an internal quality system because this is a standard within the aerospace industry. The outcome indicates whether to continue with the supplier, execute mitigating actions, or to quit the process. These outcomes are influenced by the classification of the part. If the classification is higher, then the requirements increase as well.

If a supplier passes the screening, then they proceed to the second part of the model, which is the process scan (2). The scan uses a 1 to 4 scale to score the supplier on DNA, quality, delivery, and other criteria; DNA refers to softer criteria such as culture and company size. Although there are detailed guidelines for each criteria, the model should be scored by at least two strategic buyers to reduce subjectivity. Again, the scores provide a total grade which indicates if a given supplier is suitable or if mitigating actions are needed. The model provides an overview per segment instead of weighing each criteria. This enables the buyer to judge which segments of the component are important and thus need to be met by the supplier. The segments are DNA, technology and development, and supply chain management. An example is provided in *Figure 17*, which indicates that although supplier 1 has a higher grade, they receive less points for supply chain management. This part of the model does not include a cost aspect as these are assessed in the third part of the model.

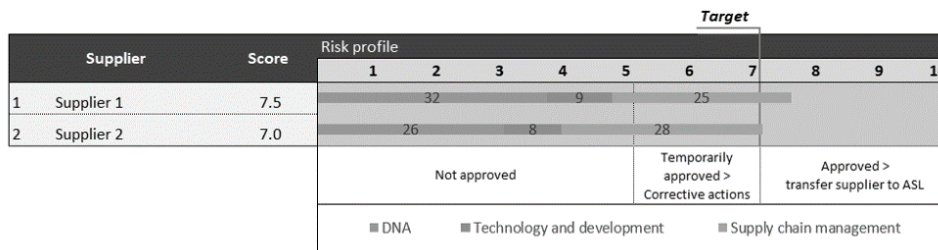


Figure 17: Supplier screening score

The third part is called the trade-off tool (3) and calculated the average price and cash outflow per supplier. Batch price, batch size, set-up cost, shipment cost, shipment size, and NRE are all put into the model to provide an overview of the expenses. Furthermore, the average price is mapped against the previous supplier score to illustrate the trade-off between cost and quality. *Figure 18* depicts an example of two suppliers with similar scores but fluctuating prices. In this case, a buyer might consider the second supplier (dotted line) because its price is competitive, the cash out at the start is low, and a high-quality score is achieved.

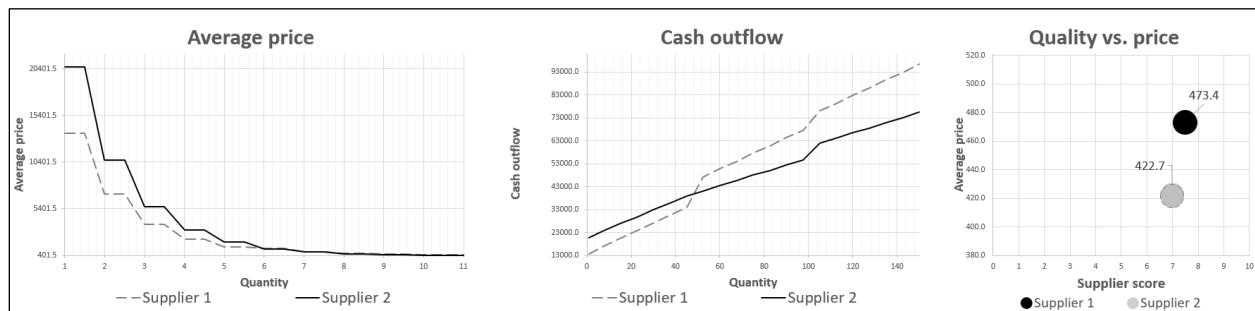


Figure 18: Supplier trade-off

The last step of the process is to select the most suitable supplier (4). In some cases, it might not be necessary to proceed through all steps of the process, such as when only one supplier is available or low-cost and non-critical items such as standard parts are bought. The process could assist with certification of an aerospace approved organization by the EASA, even though this is not necessary. The EASA (2012) has stated that vendors should be assessed before they supply items. Hence, capturing the initial scores could contribute to the overall assessment. However, some additional testing and alignment with the quality department is required to fully deploy the model in PAL-V, which should be the next step.

#### 4.4 Relationship Management

Relationship management is the last construct of the framework which is relevant to all aspects of a supply chain, just like supplier involvement. Relationships mainly involve human interaction (De Vries et al., 2014; Sjoerdsma & van Weele, 2015; van Weele, 2018b), which means that their practical application cannot simply be modelled in a manner that was possible for supplier selection. To bring this subject into practice, the design was inspired by Tony Hsieh, co-founder of Zappos. Hsieh's book (2011), *Delivering Happiness*, demonstrates how a competitive advantage can be achieved by building a close relationship with supply partners. Instead of using standard techniques, he relies on creative methods such as supplier seminars. The idea behind this approach is that suppliers are inspired to create customer value by themselves. A similar event was held by PAL-V in 2016. Nevertheless, the firm has since hardly invested in its supplier relationships. The supplier engagement program was conceived with this in mind. This program will form the base for any activities that seek to increase involvement of partners.

An engagement program could include supplier involvement days, invitations to special occasions (exhibiting shows, first power on, first flight, etc.), best supplier awards, presents, and so on. Unfortunately, there is a significant amount of time involved with organizing and maintaining these activities. That is why PAL-V's program starts with easy wins. For instance, key partners were identified and will be invited to the Geneva International Motor Show. In addition, a newsletter about the development status was sent to all suppliers. The sales department began to include suppliers in their email list. Management also remained open to any suggestions that could contribute to the program.

Although newsletters and invitations are a start, more is necessary to build a close relationships. What matters is how partners are treated which, according to Hsieh (2011), is the result of the company's culture. This means that awareness in the organization is key. Discussions with management and procurement demonstrated that both recognize the value of relationship management. Hence, building a long-term commitment and intensive partnership form the foundation for the supply chain vision and strategy of PAL-V. This means that PAL-V is willing to make an investment in terms of finances, effort, and time. Still, this strategy should be translated into actions. Since the strategy was enrolled, the following changes have been made: PAL-V is actively seeking partners, not just suppliers, for critical components. The communication frequency with suppliers has increased, also when no direct problems have occurred. Management is more involved in supplier contact. Suppliers are more often visited abroad. Last, contact is regularly face-to-face. These examples indicate an organizational shift from internal focus towards joint value creation.

Relationship management is a challenging construct to put into practice because it involves human interactions. While supplier engagement programs might help to pay extra attention to this subject, what matters is how the firm treats its partners, which is the result of the firm's culture. Therefore, awareness in the organization as well as an investment in terms of finances, effort, and time are key to building a strong relationship.

#### 4.5 A Supply Chain Strategy For PAL-V

The last few paragraphs introduced solutions for each of the four constructs of the research framework. However, during the design phase, it became clear that these separate elements could not be aligned with each other and towards the same goal without a top-level structure. For instance, there would be a conflicting result when a partner with specific capabilities is favored during the make-or-buy decision, but selection criteria focuses on cost. A supply chain strategy is therefore vital to ensure cohesion among elements and to eventually fully resolve the problem. This section will provide a supply chain strategy for PAL-V that can serve as top-level structure for all elements.

Development of the PSM strategy was a creative process that involved both management and the procurement department through a series of meetings. Books (Hsieh, 2011; Theisens, 2015), PSM articles (Hole, 2016; Liker & Choi, 2004), the focus group, examples of procurement strategies (Apple, 2018; ASML, n.d.; Audi, 2018; BMW Group, n.d.; Boeing, 2004; DAF, 2018; Heineken, 2018; Philips, 2018; Samsung, 2018; Shell, n.d.), and the design principles were used to construct the strategy. This wide range of information from different industries and sources provided inspiration as well as direction. The topic of sustainability, for example, was not discussed earlier but was mentioned in almost all company visions. This subject was presented to management and was later incorporated into the solution. The strategy that resulted from these meetings is presented below.

### ***“Making Personal Flying Mobility Happen”***

At PAL-V, everything we do is centered around making personal flying mobility happen and increasing the freedom of people while enjoying the ride. This is a challenge that will revolutionize the world of mobility and a challenge that will demand the most of us and our supply chain due to our strong focus on safety and quality. That is why PAL-V strives to build a network of innovative partners with whom we shall intensively collaborate to create shared value.

### ***Supply Chain Vision:***

*“We believe in a long-term commitment and intensive partnerships with our suppliers to bring our customers superior value more quickly and in a manner that is superior to the competition.”*

This vision is reflected in PAL-V’s supply chain strategy, which is assimilated into seven strategic pillars:

1. PAL-V will make maximum use of the capabilities of its suppliers. Hence, PAL-V will source all products unless internal development or production provides a competitive advantage for PAL-V.
2. PAL-V will involve suppliers into its new product development projects in a timely manner to increase new product development performance.
3. PAL-V will communicate openly, transparently, and honestly with its suppliers to build a long-lasting mutual relationship.
4. PAL-V strives to achieve more with fewer suppliers and will therefore only select world-class vendors that share PAL-V’s mission and vision. Subsequently, PAL-V will share risks and rewards with those suppliers.
5. PAL-V will together with its suppliers strive to continuously improve its product, processes, and services.
6. PAL-V strives for dual sourcing of competences unless single or multiple sourcing of products is required or possible.
7. PAL-V pursues a sustainable supply chain. Hence, suppliers are expected to provide a safe and healthy working environment and to operate in an environmentally responsible and efficient manner.

A policy on global sourcing was added in addition to the strategic pillars. Currently, PAL-V is identifying opportunities to source more globally than before. However, PAL-V is aware of the attendant risks such as cultural differences, communication issues, different time zones, or political conflicts (Bogers et al., 2018; Meixell & Gargeya, 2005). Therefore, PAL-V prefers its supplier to be within Europe, especially for critical items (i.e., part 1) that are ideally sourced as close as possible. PAL-V has set its sights on Eastern and Southern Europe to combine low wage costs and the key competences of suppliers for less critical items. An extensive sourcing procedure has started to effectuate the global sourcing policy.

Obviously, the supply chain vision, strategic pillars, and global sourcing policy are linked to the research framework and business strategy. Nevertheless, the practical application of the constructs is presented in the past few paragraphs, which provided the design elements. The strategy only unifies these elements towards the same goal of building a supply chain that supports PAL-V's "future" business strategy.

#### 4.6 Implementation and Evaluation

This chapter would be incomplete if it omitted to discuss the implementation of the solution within the focal firm. It involves organizational change, which is often paired with resistance because people do not like renewal (Theisens, 2015). Van Aken et al. (2012) have stated that the focal firm must be involved to substantially reduce resistance. That is why implementation is nested in the nature of the design approach. Each iteration is a small deployment of the solution to actively involve the stakeholders. These actions took place on three levels of the organization.

The first level is the procurement department, which will execute and work with the proposed solution. They contributed to the solution design during weekly progress meetings and did not form any resistance as they acknowledged the necessity. The strategy, planning, and selection models were all successfully deployed within the department.

Management was the second level, and their support is critical for the success of the solution. Results were presented on a recurring basis; topics were added to management agenda; and management participated in several sessions, including the meeting of minds. Implementation led to the support of the overall design. Several results such as the BMC, spend analysis, KPM, and PSM strategy were included in the corporate documentation and presented to (potential) investors.

The third level is the engineering department that is directly affected by the solution. Engineers were expected to object the most to the proposed design because they encountered the most significant change. For instance, some engineers have been working for over 5 years on a design and always assumed that they would assemble and test it for production. Now, due to a new strategy, the supplier is involved more closely and might execute some of these actions. The conflicting overall business objectives and personal interests were carefully managed. Engineers were involved as often as possible. Clear explanations were provided to them, they were guided through the process, and their feedback was incorporated into the solution. This resulted in a cultural shift. The engineers and the organization as a whole were more open towards cooperation with suppliers, which is one of the most significant results of this research.

## 4.7 Revised Research Model

This chapter discussed the solution design for PAL-V's missing supply chain. A fifth element was added in addition to the four constructs that were discussed in the literature review. This element took the form of a supply chain strategy to ensure cohesion among the other constructs. This required revision of the research model because the case study demonstrated that the constructs might be doomed to fail on their own. *Figure 19* demonstrates how a supply chain strategy and business strategy are added as a top-level structure. The business strategy could also be viewed as part of the business context in which the firm operates. However, the link between the two is so apparent that it is displayed in the model. A similar note to the illustration applies to the whole framework, which is presented in a simplistic visualization while in fact all elements are interconnected.

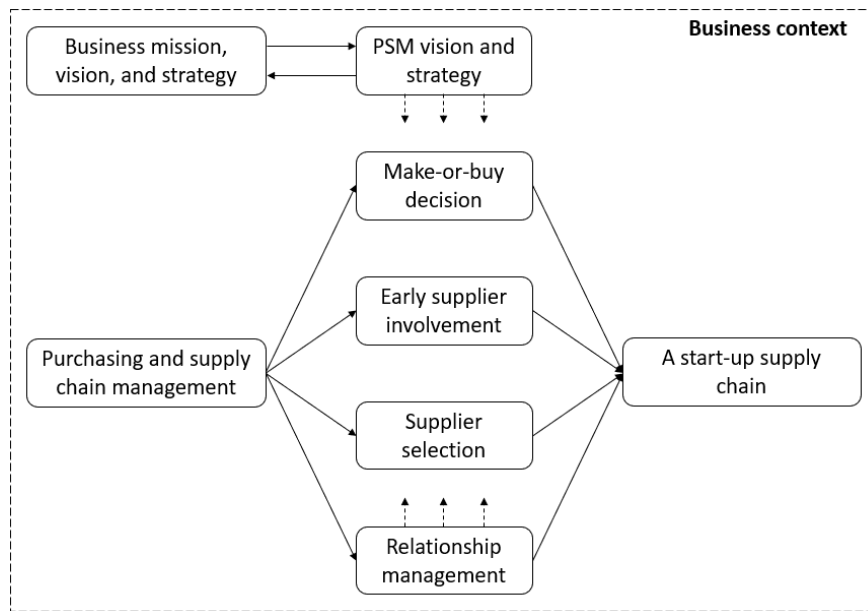


Figure 19: Revised research framework

## 4.8 Summary from Solution and Implementation

This chapter provides a solution design for the missing supply chain of PAL-V. The research framework formed the base for the solution. However, during the design, it became apparent that an extra construct was necessary to align the design elements. That is why a PSM strategy was defined to ensure cohesion among the six solution elements. This made it possible to reconsider the make-or-buy decision for four activities. Two of those were modified to align with the new strategy, which meant that partners must be found and involved. Involvement of suppliers will be empowered by two design elements: a commodity strategy and supply chain planning. The commodity strategy guides appropriated decisions on the supplier and component levels, while the planning bridges the gap between the engineering and procurement department. If procurement is better informed about upcoming requests, then they should be able to better facilitate supplier involvement. However, involvement of suppliers can only succeed if the right partner is chosen. For that reason, the design revised an existing selection model, which now scores vendors on a balanced set of criteria pertaining to quality, delivery, and culture. Moreover, involvement requires a relationship that is built on trust. The design therefore focused on the human interaction between organizations. This led to multiple changes to PAL-V's relationship management, such as more frequent face-to-face meetings with critical partners. The internal stakeholders should be considered as well. The departments of procurement, management, and engineering were closely involved during the design to secure their acceptance of the solutions.

## 5 Discussion and Conclusion

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This chapter discusses the main results that can be derived from this research study. It starts by examining the theoretical implications for PSM and start-up literature. Next, managerial implications for new ventures are presented, followed by specific implications for PAL-V. The chapter answers the research question and presents the overall findings in a final conclusion.

The research aims to explore how start-ups could build a supply chain to support their business strategy. Prior PSM research does not address the challenges faced by new ventures. A research framework for start-ups was composed (*Figure 19*) after the knowledge-generating process. The framework, consists of a business context in which new ventures operate, a top-level structure (business and PSM strategy), and four constructs: the make-or-buy decision, supplier involvement, supplier selection, and relationship management. The framework is not a stepwise model because constructs are interconnected and should be resolved simultaneously. However, some logical order exists.

Start-ups are embedded in a business context which should be considered when developing a supply chain. A spend analysis should be performed before the firm can define a strategy. Even though information might be limited within new ventures, a spend analysis could provide an in-depth understanding of the cost and product structure, supply challenges, and supply base. These insights should lay the foundation for further development. The CRISP-DM could serve as a source of inspiration because current literature lacks a clear methodology for the spend analysis. This method allows for consistency, repeatability, and objectivity (Provost & Fawcett, 2013).

The business and PSM strategy are displayed at the top of the framework. The research found that these are vital to ensure cohesion among all elements because there is no single solution to the whole problem of a missing supply chain. Moreover, the study revealed that close involvement of management is desired in this phase. The considerations are strategic and should not be made by the procurement department alone. This is in line with prior research which has emphasized the importance of aligning the PSM strategy with the company's overall objectives (Batenburg & Versendaal, 2006; Monczka et al., 2009; van Weele et al., 2017; Virolainen, 1998). Finally, strategy definition should not be a one-off action; instead, the strategy should be revised constantly to account for changes in the product or supply base.

The make-or-buy decision should be made after the corporate strategy is defined. In contrast to what the literature had implied, TCE is less useful for start-ups to guide organizational boundary decisions. While transaction costs cannot be omitted, they should never be leading considerations. The make-or-buy decision should rather be based on protecting IP and capitalizing the core competences of the firm. Thus, the choice is strategic and competence driven, which makes the RBV a more suitable theoretical framework than TCE.

It is also important to involve and engage suppliers for the outsourced components. The case-study confirmed the findings of Song and Di Benedetto (2008) that involvement could improve start-up performance if managerial challenges are overcome. However, the study also demonstrated that involvement might be especially challenging for start-ups due to the unwillingness of suppliers to be involved, the lack of established contacts, and the power imbalance between parties. Essentially, involvement is about building trust and a relationship between supplier and buyer. Relationships concern human interaction, a complex aspect for which the strategic, operational, and collaborative processes must be in place. Without these processes, it would be impossible to share knowledge across firms. The KPM and Wynstra's involvement matrix proved to be practical tools for selecting collaboration and communication structures. In addition, a start-up might be able to explode its marketing appeal or growth potential to increase the vendor's willingness to cooperate. The case study has demonstrated that even



multinationals were willing to engage after global recognition of the product. Other aspects that should be considered are timing and location. First, suppliers should be involved timely into NPD which tends to be as early as possible for critical items. It often takes a long time to involve suppliers because the network and relationships have yet to be established. Building trust and a relationship takes time. Hence, new ventures should start by involving important partners from the beginning. Second, start-ups might prefer suppliers geographical proximity because it facilitates communication. Proximity was revealed by the case study and the external PSM experts to be beneficial. That does not mean that start-ups should not source globally; rather, it means that they should do so with care. In essence, a close relationship must be built with suppliers if the company is to benefit from involvement.

Supplier involvement can only succeed if the right supplier is selected. Supplier selection, the third construct, is thus a critical step when building a supply chain. Selection criteria and methods might differ based on the new venture's strategic objective. Nevertheless, considering cost alone seems to be too short-sighted. Instead, the research has revealed that start-ups should guide supplier selection with a balanced set of criteria of quality, delivery, and culture, that is based on a secure foundation of prior stages. This means that even if a start-up could appeal to a larger firm due to its marketing value, it might be better to engage with smaller and more equal business partners as this results in greater involvement.

Relationship management might be the most important and the most difficult construct to put into practice. The reason for this is that relationship management is interconnected with all other elements and involves human interaction, which cannot be modelled. What matters is how the firm treats its partners, which resolves from the company's culture. The firm should be aware of the importance of relationships, and management should propagate how to cooperate with partners. Effective supplier relationships must be built from the ground up. This takes time, but also provides opportunities because vendors do not indicate bias. Hence, trust should not be damaged along the way and the new venture should communicate openly, honestly, and frequently with its suppliers.

The framework does not address how the solution should be implemented within a start-up. Conflicts between company's objectives and personal interests should be managed carefully. Engineers in particular could be a source of resistance if they are not correctly guided along the process.

## 5.1 Managerial Implications

Our research confirms that a supply strategy in the form of a top-level structure that is aligned with the overall business objective is vital for building a supply chain. Management should be closely involved in the early stage because the supply chain considerations are strategic. For instance, if the core competences are clearly expressed by the board, they become a rigorous foundation for further considerations such as the make-or-buy decision, which will follow naturally.

The research further revealed that costs should never be decisive in supply chain decisions, although this might be common practice for some firms. A start-up is characterized by limited resources; hence, cost cannot be omitted. Nevertheless, there are more important criteria than cost and price only. Criteria should include culture, quality, delivery, or sustainability. Managers should use a balanced set of criteria as guidance. This applies to the make-or-buy decisions, supplier selection, or other topics. A useful illustration might be a non-critical fastener which could be bought anywhere. However, if that fastener is missing due to poor delivery by the supplier, it could delay production process.

Another vital insight is the importance of relationship management. This aspect should be a priority for managers who want to build a supply chain. Establishing a partnership could be difficult because it involves human interaction. This requires awareness in the organization and a culture of cooperation. A firm should communicate openly, frequently, and honestly with its partners to strengthen the

relationship. Of course, time is limited, and priorities for key supplier must be set. Nevertheless, relationships with other vendors should not be neglected.

## 5.2 Implications for PAL-V

The main objective of this research was to design a solution for the missing supply chain of PAL-V. This paragraph will present recommendations that should be executed to accomplish this objective. The implications are subdivided into three parts: implications for the solution design, further steps, and a strategic consideration.

Our proposed design covers six elements: the PSM strategy, make-or-buy analysis, commodity strategy, supply planning, selection models, and engagement program. While all elements contribute to the main objective, none of them are static. Thus, further deployment is required to fully resolve the problem statement. The PSM strategy should preferably be revised and aligned with the overall business strategy on a recurring basis. Subsequently, adjustments in the PSM strategy must be applied to the other elements to preserve cohesion. A similar remark applies to the commodity strategy. Internal and external changes could impose new supply challenges. A design change towards an alternative production technology, adjustment of materials, political conflicts, or supplier bankruptcy could have major consequences that should be accounted for. The printed circuit boards (PCB) illustrate one such example. PAL-V had to quickly adjust to a former PCB supplier, which abruptly stopped collaboration. This indicates that continuous improvement is necessary which is in line with the cyclic purchasing model (van Weele et al., 2017).

The outcomes of make-or-buy analysis are serious. Both rotor blade production and welding shifted from in-house production to outsourcing. Thus, a partner had to be found on short notice. Three measures should therefore be taken: the sourcing procedures should continue, a purchasing specification should be made, and the responsible engineers should be involved. The purchasing specification will facilitate the RFQ to gain information about the supplier. In addition, a significant amount of knowledge must be transferred when the supplier is chosen; thus, engineering involvement is vital.

The planning should also be updated and monitored continuously during the weekly team lead meeting in which it was deployed. If changes are made, the team leader or management should intervene. Otherwise, the deadline might not be met.

The proposed supplier selection models requires further testing. A strategic buyer (van Dijk & van der Braak, 2018) has argued that the former model was too complicated and too time consuming for use during the supplier selection phase. His recommendations were incorporated as much as possible, but our proposed model should still be fine-tuned because it was only tested once for the PCB vendors. Criteria and their weight might have to change, be deleted, or added to. In addition, the selection model is part of the larger picture, the supplier selection procedure, which is being revised. The revision is part of an improvement project that is outside the scope of this research.

The last design element is the engagement program. The program is used as the reference for all activities pursuing to build strong supplier relationships. Several measures must be taken in the future to form a connection with key suppliers. Some examples of these measures include a supplier involvement day, supplier award, supplier community platform, and so on. However, the program is not about organizing fun events or showing of. Instead, it is about trying to build a relationship through open, honest, and frequent communication. PAL-V should keep pursuing these relations as is stated in the PSM strategy. Hence, an investment in terms of finances, time, and effort should be made by PAL-V.

Second, our research addressed the strategy and sourcing, which are the first two phases of the cyclical purchasing model. Implementation and management, the other two phases were outside the scope of the research. Nevertheless, it became clear that new challenges arise in these latter two phases during the study. For instance, PAL-V has sourced, selected, and contracted suppliers who now have to be audited. The alignment between quality systems to demonstrate the design conformity required by EASA (2012) has proven to be challenging. It involves both general and component-specific arrangements that all must be documented. Other challenges include further deployment of the ERP system, improving processes, evaluating suppliers, and more. Therefore, a new project should be started to identify and resolve challenges for the coming phases.

Third, PAL-V initially stated that the cost price of the vehicle should be reduced because this was one of the three main corporate objectives (PAL-V, 2018). This cost aspect featured in several discussions throughout the study. It started with the focus group in which the PSM experts questioned why PAL-V was so concerned with cost (Bogers et al., 2018). They argued that PAL-V is an innovative leader that should instead pursue the highest quality. Naturally, the lowest cost would provide the highest profit. Nevertheless, throughout the study, cost was never favored over quality or safety in each discussion on supplier or component level. Management questioned if a lower price would lead to an exponentially greater demand. In other words, question arose over the elasticity of price. This question requires further attention because no answer was provided.

### 5.3 Answering the Research Question

The overall objective of this research is to answer the main research question:

***How can a highly innovative start-up build a future-proof supply chain to support its business strategy?***

Several underlying sub-research questions are defined to support the main question. These questions will be answered in this paragraph.

#### **1. How does PAL-V's business strategy look like, now and in the future?**

Internal documentation of PAL-V and discussions with management have revealed that PAL-V is a technologically driven company that focuses mainly on R&D activities to acquire type approval for its vehicle. Initially, PAL-V was internally oriented. However, throughout the course of this research, the firm shifted its strategy and culture towards a greater external focuses. Moreover, the firm expects a steep ramp-up after the second year of production.

#### **2. How to resolve the make-or-buy decision for PAL-V?**

PAL-V has resolved the make-or-buy decision in five steps. First, PAL-V identified four opportunities to be reconsidered for inhouse production or outsourcing. Second, an extensive analysis of resources, capabilities, pros, cons, and other was performed to validate the former make-or-buy policy. This was the most important step for which the core competences of the firm were decisive. Third, the analysis resulted in alternative decision for two of the four opportunities. Fourth, the changes were implemented which meant the commencement of a sourcing procedure. Fifth, the policy for the make-or-buy decisions was changed to fit the externally oriented strategy.

### **3. How to involve specialist suppliers to both PAL-V's innovation process and operational process?**

Connecting suppliers to the innovation process of PAL-V was not possible because the design was in the final phase of development. Nevertheless, PAL-V has set new strategic objectives to incorporate suppliers timely into coming NPD projects. It is anticipated that involvement will be easier because the future supply base could serve as a foundation. PAL-V has implemented four measures to establish that supply base and connect to suppliers. First, it has defined a PSM strategy to ensure cohesion among all elements. A detailed commodity strategy was derived from the general strategy. Both plans guide appropriate decisions on the supplier and component levels, such as the selection of the right communication structure.

Second, PAL-V has implemented a supply chain planning that seeks to bridge the gap between the engineering and procurement department. This ensures that procurement will be informed about upcoming requests. Hence, the schedule enables procurement to better involve suppliers better in the development process because they can fulfil a supporting role between engineers and suppliers. Third, supplier selection tools were implemented to ensure that the most suitable vendor is chosen. Finally, PAL-V significantly invested in relationship management to enhance its partnerships. It creates awareness in the organization about the importance of relationships and aspires for communication that is open, honest, and frequent.

### **4. How to qualify and select the right partner for PAL-V?**

PAL-V has implemented three tools for supplier qualification and selection. The first two tools qualify suppliers with a balanced set of criteria on quality, delivery, and culture. The last tool creates an overview of the total expenditures and qualifications to support a well-considered trade-off between cost and quality. A procedure was set for the tools; however, steps might be skipped depending on the complexity of the selection.

### **5. What are the consequences and implications for PAL-V's (procurement) organization and systems?**

The implications for PAL-V's procurement organization are three fold. First, the solution design consists of six elements that require continuous revision because they are not static. External or internal changes could create problems which should be accounted for by the procurement organization and design. Second, this research focused on the first two stages of the cyclical purchasing model. A new project should start to identify and resolve challenges for the other two phases. Finally, a question about the price elasticity arose during the research but remained unanswered. Therefore, further research on this question should be conducted.

## 5.4 Conclusion

Our research aims to explore how start-ups could build a supply chain to support their business strategy because prior PSM research not provide any guidance. PAL-V, a start-up that brings the first commercially available flying car to the market, is a as real-life case study that helps to explore this literature gap. The research found through the knowledge-generating process that four constructs are vital when building a supply chain for a start-up: the make-or-buy decision, supplier involvement, supplier selection, and relationship management. These constructs should be aligned with the overall business objectives of the firm and can only be resolved if the company understands the business context in which it operates. Therefore, a start-up should commence by analyzing its business context and creating a supply chain strategy before deciding about new product design. If the context is clear, then the start-up should decide what to make or buy. This consideration should be based on protecting IP and capitalizing on the core competences of the firm. Hence, the RBV could serve as suitable framework.

For outsourced components, it is important to involve suppliers which essentially is about building trust between suppliers and buyer. The strategic, operational, and collaborative processes therefore must be in place. A start-up might be able to capitalize its marketing appeal or growth potential to increase the incentive for the vendor to be involved. These suppliers should be involved in the NPD process in a timely manner which tends to be as early as possible for critical items. It often takes a long time to involve suppliers because the network and relationships have not been established yet. Supplier proximity might be favored by the start-up because this facilitates communication. To put it differently, global sourcing should be carefully considered. Nevertheless, supplier involvement can only succeed if the right supplier is selected. Selection should be guided by a balanced set of quality, delivery, and culture criteria with groundwork from prior stages. However, the last three constructs cannot succeed if relationships are neglected. New ventures should be aware of the importance of relationship management. Building a partnership takes time; hence, start-ups should not damage trust along the way and communicate openly, honestly, and frequently with its suppliers.

## 6 Limitations and Future Research

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The results of this study should be viewed in light of some limitations. First, a single case study was conducted, which has weaknesses for theory building. Eisenhardt (2016) has argued that case studies could yield overly complex theory which might be narrow and idiosyncratic. Hodkinson and Hodkinson (2001) have added that such research cannot be easily generalized. Therefore, one should be cautious in applying the result to other new ventures. Further empirical studies at multiple start-ups must be conducted to validate the research framework and its applicability. These studies should also consider the innovativeness of the firm because there might be a difference between radical and incremental start-ups. Song and Di Benedetto (2008) have suggested a similar direction but focus only on whether supplier involvement is as critical in all cases. Furthermore, different industries and countries could have different results.

Second, the research concentrated on four dimensions of building a supply chain for new ventures: the make-or-buy decision, supplier involvement, supplier selection, and relationship management. Other measures that might be relevant were not included. For instance, the four dimensions focus mainly on the first two stages of the cyclical purchasing model. Implementation and management, the other stages, are not addressed by the study. An extension of the research framework might provide additional perspectives on these topics.

Third, the research framework was visualized simplistically. There are, however, most likely interconnected relations among constructs. Relationship management is particularly expected to have moderating and mediating effects alongside a direct impact on the performance of start-up's supply chain. Moreover, the correlation factors of the constructs could not be measured given the qualitative nature of this study. These measurements require further empirical research. A numerical representation would not only be informative for the research framework but also for the constructs. For example, supplier selection criteria among different start-ups could be measured to indicate appropriated weightage. Softer criteria might be especially interesting because the suggestion to include such principles is relatively new (Schoenherr & Wagner, 2016).

The results of the study contribute to the academic field despite the limitations of the case study. The subject of building a supply chain for new ventures, has not been addressed in prior research. Eisenhardt (2016) have stated that if little is known about a phenomenon, then it is particularly appropriated to build theory from case study research. This view is supported by Flyvbjerg (2006), who has expressed that case studies could contribute to scientific development.

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# Appendices

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