Cost Efficiency and Waste Reduction in Completely Knocked Down Production
This final thesis work has been carried out at the Technical University of Jönköping within the area of Industrial Engineering. The author herself responds to opinions, conclusions and results presented.

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Abstract

**Purpose** – To provide a framework for the improvement of the supply chain of Completely Knocked Down Products with a focus on waste reduction and cost-efficiency.

**Method** – A case study at a company dealing with CKD assembly, based on observations and interviews. Triangulation of several sources from scholarly articles, examples from the automotive industries and researches. This investigation has been designed to provide logic and coherent structure backing the purpose following the red-thread of answering the research questions. The objective of the study is achieved combining literature review and a case study mainly based on observations and interviews.

**Results** – CKD production can be beneficial depending on the specific content and market conditions. This thesis focuses on value creation throughout each stage of the production of CKD, from design to final assembly. The study found some guidelines that should be followed in managing the supply chain of CKD products. It fills a vacuum of knowledge on the topic.

**Implications** – The frameworks resulting from the research, highlight the actions to be taken to implement CKD efficiently, with minimum waste and cost, leading to an overall improvement of the entire supply chain.

**Limitations** – There have been found limited resources on the topic. Developing a framework without thorough examples from different industries contexts was a limitation due to the absence of available information. Observations and interviews limited to one company that locally assembles globally sourced parts.

**Keywords** – Completely Knocked Down; lean manufacturing; value chain; supply chain improvement; global manufacturing.
Summary

Moving towards a CKD strategy could be a cost-cutting methodology. Local assembly of knocked down products globally sourced in the form of kits could represent the middle ground between a global and a local strategy. Companies could benefit from tax deduction resulting from local assembly, gain access to new markets and expertise.

CKD manufacturing requires companies to maintain excellent relationships with their suppliers, sharp logistics organization and clever packaging. The aim is to minimise logistics costs. Management commitment, efficient quality management are other factors to ensure effective supply chains. For a company to decide to deal with any kind of Knocked Down strategy has to be carefully evaluated.

The problems and advantages of such a strategy need to be analysed and compared, to evaluate its advantages on the company’s strategy. Currently, companies cannot rely on a framework to help them take the decision to adopt CKD, nor to help them with implementation and control. CKD does not fit all markets or industries. It is a strategy requiring well-thought planning and that is usually carried in a specific context where it brings benefit to the company. The strategy does not provide the final product with any additional value. The benefits lay in the organisational advantages. The main one being the reduction of costs or tax and government incentives. CKD supply chain is complex and requires good supply chain management behind it. The topics of Global Manufacturing Networks and Glocalisation provide ideal situations in which CKD strategy would function at best. For already established CKD supply chains, once established the appropriate performance metrics and standards and having defined where the main problem lay, it is easier to come up with suitable solutions. The organisation should keep a mentality of continuous improvement and adapt to the market requirements. Having ensured excellence in communicating with suppliers and jointly address issues, quality is also insured, and it should not come at a high cost. Lowering total costs, not just unit raw material cost and maintaining a stable demand, despite market changes is considered ideal to keep relationships with suppliers optimal.
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1 Introduction

This section gives a background to the investigation carried out and the problem area around which the study was built. The purpose and the aim are presented and the relative research questions raised are outlined. Furthermore, the scope and limitations of the study are described. The section ends with an outline of the report, to make the information presented easily accessible.

1.1 Background

Many companies today are in one way or another global. Supply chains are getting longer and more geographically distant actors are involved. This makes accurate planning essential, especially in the manufacturing sector, where production is dependent on the arrival of parts from all over the world. The success of an organization nowadays depends on the management skills and ability to integrate other parts and players of the supply chain so as to reduce costs and add value to the final products (Soares, et al., 2008). Optimising processes, focusing on the value chains and minimising any sort of waste should fall under the main priorities for any company. Increased interdependence of national economies and cross border movement of products, labour, information and technology is why firms decide to go global. However, this decision also causes an increased risk in the supply chain originating from transparency and tracking issues. Buying versus building is the basic decision in globalisation, led by strategical internal development and acquisition, licencing and partnerships (Gong, 2013).

Globalisation refers to the growing global scale interconnectedness and integration of human activities. Currently, it includes phenomena such as cross border integration of wholesale and retail financial markets; increased global scale market competition; increased Foreign Direct Investment (FDI) and increased cross border contracting and production networks as well as international joint ventures and strategic alliances (Sturgeon & Florida, 2000). Apart from risks and opportunities, globalisation brings new costs of transportation, tariffs, taxes and duties (Yavari & Isvandi, 2018). These factors need to be considered in the trade-off analysis when choosing to go global.

Opposite to global production is the trend of promoting local growth by governments. Protective instruments such as tariffs, controls and quantitative restrictions have been ways for governments to actively promote local growth through incentives, local content regulations and tariffs that makes it advantageous to produce locally (Humphrey, 1999).

There is a recognised growing tension between local and global sourcing. The choice of buying versus building comes down to the key drivers of a specific company. Many producers’ ultimate goal is to scan the world for low-cost, high-quality parts. But global sourcing is being inhibited by the need for suppliers to become involved early in the design process and by local rules that can block the shipment of low-cost global sourcing materials or parts (Sturgeon & Florida, 2000). It is not only lower labour costs or the avoidance of import tariffs that drive shifting production or supply chain steps to low wage countries. Strategic aspects like hedging currency risks and building up a global sourcing base are taken into account (Schwede, et al., s.d.). This adds to the complexity of the global supply chain design. In a global supply chain, understanding total logistics cost and ensuring flexibility requires integration between supply chain planning, forecasting, transport procurement and operations such as consolidation and packaging (Ludwig, 2011).

Locally procured parts are on average more costly than those purchased globally. The latter tend to be highly standardised, easily transportable and subjected to low tariffs compared to those procured locally which allow greater customisation and subjected to higher tariffs. However many of distant assembly producers for Ford and General Motors, began to source parts and materials locally, both from outside suppliers and through building up internal capabilities due to tariffs duties being often high with the presence of existing domestic parts and material producers (Sturgeon & Florida, 2000).
Moving towards a Completely Knocked Down (CKD) strategy could be a cost-cutting methodology. Local assembly of knocked down products globally sourced in the form of kits could be seen as the middle ground between a global and a local strategy.

Trade barriers hindering importation of products are considered the primary drive for the adaptation of KD production (Coia, 2012). With high customs duties and restrictions on market access, producing CKD allows companies to produce locally, closer to the market, at competitive costs (Abele, et al., 2008). Adopting CKD has great implications for a company. It requires carefully planned logistical operations, close integration and exchange of information between suppliers and final product assembly. Generally, CKD rises the variable production costs but it can lower fixed costs since the factory does not usually require a particularly complex set of equipment or of high-end technologies.

Some research shows that CKD assembly while growing in importance, is becoming increasingly difficult due to local rules that require a fast transition to local sourcing and due to the problems arising from the JIT production system, where parts come from the original factory sequenced for assembly (Sturgeon & Florida, 2000). There is currently little research available on the subject of CKD manufacturing and mainly related to the automotive industry (Erfurth & Bendul, 2018). Therefore CKD manufacturing can be considered a relevant subject to investigate in the global and interconnected industry world. The benefits of formulating a model or a framework for better practice within CKD manufacturing could be enjoyed industry-wide and improve the overall supply chain efficiency, minimizing costs and risks.

1.2 Problem Formulation

Global supply chain networks require visibility, planning and an efficient management strategy. Their increased complexity and a great deal of interconnectedness and exchange of information make the management of the supply chain an everyday challenge. Most of the stages of a global supply chain happen at different geographical locations (Abele, et al., 2008). Particularly, CKD supply chains are generally spread across continents.

CKD manufacturing requires companies to maintain excellent relationships with their suppliers, sharp logistics organization and clever packaging. All with the aim of minimising logistics costs. In fact, it generally costs more to ship completely knocked down kits than to order separate parts. However, the benefits of such a strategy can be many. For a company to decide to deal with KD has to be carefully evaluated. As previously mentioned, in some cases the higher costs rising from CKD purchasing is balanced by the advantages and the incentives given to assemble the final products locally, but this alone is not enough for taking the final decision of getting along with CKD production.

The problems and advantages of such a strategy need to be analysed and compared, to evaluate its advantages on the company’ strategy. Currently, companies cannot rely on a framework (Erfurth & Bendul, 2018) to help them take the decision to adopt CKD, nor to help them with implementation and control. There is a need to come up with guidelines and models for industry sectors.

The main problems within CKD manufacturing as identified by the works from the University of Porto and Aveiro are summarised in the following list:

- Large inventories accumulation due to the quantity of CKD ordered not being coherent with production or sales rate;
- Long lead time causing discontinuation of production flow and queues;
- Build-up of scrap;
- Delays in supplying the assembly line, reflecting in delays in final distribution;

(Freitas, et al., 2017)
These drawbacks can have huge impacts on the overall performance of the company. To avoid them and to take full advantage of the benefits of CKD is key to improve the supply chain. Lack of information on CKD among the academic world highlights the need for this study.

1.3 Purpose and research questions

The problem description above gives an overview of the potential of completely knocked down manufacturing and on the lack of available information. There is currently little research on KD supply chains and on possible improvement measures (Erfurth & Bendul, 2018). This investigation comes to supply some of the much-needed information on the subject in order to make best use of Knocked Down production. The main purpose of the study is:

*To provide a framework for the improvement of the supply chain of Completely Knocked Down Products with a focus on waste reduction and cost efficiency.*

By providing the industry with a discourse on the key drivers, advantages and drawbacks of Completely Knocked Down strategy, this study aims at expanding the available knowledge on such a production approach. Improvement of flow through minimisation of waste and risks is the focus of this investigation. This is achieved by comparing previous studies carried out in various industries and the literature, as well as through direct observation of waste-related procedures at a company dealing mainly with CKD products. Lean philosophy, transaction cost economy and the concept of value chain constitute the study’s conceptual base. The goal is to make the findings applicable to different situations in a variety of industry fields.

To achieve the purpose stated, the problem has been broken down into three research questions (RQs):

*RQ1. How can a company adapt its supply chain for CKD manufacturing?*

The answer to this question provides a general overview of the advantages of Completely Knocked Down. The problems that might arise are also outlined.

*RQ2. What are the main causes of waste and cost within CKD manufacturing?*

Focusing on the value chain of the products delivered should be the aim of any company willing to be competitive in the market. This requires waste elimination, which first should be defined. As Peter Drucker claimed, “*if you cannot measure it you cannot improve it*”. By defining what the waste is, it is possible to find the root cause and eliminate or reduce it.

*RQ3. How should a framework for the supply chain of CKD products be designed?*

Achieving an improved supply chain where waste is reduced and costs are minimised, requires effective and efficient communication among the various actors. Excellent knowledge of the process and good control are also necessary. By answering this final question, a framework for an efficient supply chain of CKD products is outlined, with the aim of providing companies with the best way to adapt or improve the supply chain of CKD products.

1.4 Scope and Delimitations

The focus of this investigation is to provide with a thorough framework for the improvement of the supply chain of CKD products by coming up with a way to maximise value while minimising waste and costs. Because of the increasing complexity of supply chains (Ludwig, 2011), it would require many unavailable resources to find improvement frameworks for all the stages. For this reason, this study particularly focuses on improving the relationship between producers and suppliers, the internal communication and integration of companies adopting CKD
manufacturing, touching on forecasting accuracy in a globalised environment and the issue of lead times and order quantities. These aforementioned factors, even if seemingly unrelated are interconnected and fall into the topic of supply chain management. If managed correctly, they can all contribute to positive results for creating and sustaining efficient chains.

The research has been based on the limited available research found. Most of the examples come from the automotive industry. The lack of previous studies made the development of a general framework particularly challenging.

The observations and interviews are limited to one company that locally assembles globally sourced parts. The market and industry context represent another limitation because of its location in a developing country. The results might be difficult to apply to developed markets, even though the analysis has been kept as generalised as possible. Issues of cost savings cannot be included since they are greatly dependent on the type of products.

By knowing the limitations, the study can be adjusted to different contexts in a more reliable manner in order to take advantage of it in the best way depending on the needs of the company. Figure 1 illustrates the main areas this investigation focuses on and their relationships.

![Figure 1 Summary of areas of focus in the reduction of waste](image)

*Figure 1 Summary of areas of focus in the reduction of waste*
1.5 Structure of the report

The content of this investigation is divided into different chapters as pictured in Figure 2 which also clarifies the connection between the sections.

The investigation opens with an introduction of the topic addressed and the problem proposed, which lead to the outline of the aim of the study and its delimitations (Chapter 1). Chapter 2 describes the methods used to collect data to achieve the purpose of the investigation. The work process is explained and justified. Finally, the chapter presents information related to validity and reliability of the study.

A Theoretical Framework constituting the knowledge base for this investigation is provided in Chapter 3. Relevant definitions and literature references are outlined, together with industry examples of Completely Knocked Down manufacturing. Chapter 4 contains the outline of the findings and the results of the case study.

Chapter 5 is the Analysis of the findings outlined in Chapter 4 combined with the theories provided in Chapter 3.

The thesis ends with discussions and conclusions drawn from the investigation, where all the information provided in the previous chapters is summarised and critically analysed.

Additionally, suggestions for further research and areas of improvements are provided.

Figure 2 Structure of the report
2 Method and Implementation

The following chapter presents information regarding the methods used for the collection of empirical material necessary to achieve the purpose of this study. The work process is explained and outlined in a timeline. The methods used (literature review, observations and interviews) are described and justified. The chapter ends with information concerning the validity and reliability of the investigation.

2.1 Research Design and Approach

This investigation has been designed to provide logic and coherent structure backing the purpose following the red-thread of answering the research questions. The study purpose is achieved by combining literature review and a case study mainly based on observations and interviews. Direct observation was carried during 4 months of internship along with in-depth research on available cases and theories. The investigation takes a qualitative approach to answer the questions introduced in the first section of the report. Qualitative research consists of an investigation that seeks answers to questions through the collection of evidence and following a predetermined set of procedures, with the aim of producing new findings applicable beyond the immediate boundaries of the study (Mack, et al., 2011). The three most common qualitative methods are participant observation, in-depth interviews and focus groups. Multiple sources of relevant evidence, logical and convincing arguments make good qualitative research (Flick, 2013).

Topics of more quantifiable nature such as the question of waste and costs in RQ2 have been sometimes approached through a quantitative research method. A quantitative research method differs from the qualitative since it uses a more structured method and delivers numerical data (Mack, et al., 2011). Generally, qualitative research can be open-ended while quantitative ones deliver tangible data. The discussion and conclusions are found through an inductive approach based on the explorative results. The explorative approach is a necessary condition of the investigation due to its mainly unexplored subject (Klevensparr & Meirvert, 2014).

The setting of the company offers opportunities in terms of understanding globalisation and localisation trends, as well as the way particular socio-economic contexts affect production. The empirical material in the form of literature review presented is resulting from triangulation of multiple sources: academic articles, research theses and public reports.

Figure 3 below graphically represents which methods have been used to answer each question.
The study was carried out during 6 months, with different stages of the investigation being completed at different times. Before outlining a strategy and methodology, some background research was necessary. The theoretical framework was built in combination with the first stages of the observation phase. According to the findings, more theories were required to explain some trends or facts observed. The analysis represents the last phase of the research process. Figure 4 visually summarises the timeline of the investigation.

The discussions and conclusion are based, aside from the results of the investigation and the research carried, on the knowledge gained during the studies in Industrial Engineering and Management, which this investigation seeks to conclude.

2.2 Collection of Empirical Material

It is essential for the investigation to be credible and reliable, to base the studies, hypothesis and conclusions on accurately researched and solid empirical material. For this thesis, empirical material has been collected mainly through observations and interviews, as well as analysing real-life industry examples of Knocked Down manufacturing in several scholarly articles.

Figure 4 Timeline of research process
2.3 Literature Selection

Theories and examples have been investigated and found through different resource databases. Among them, Primo Library Search (Jonkoping University’s database); Emerald and Jstor. The search of relevant sources was methodically carried, by selecting some keywords to be typed in the database’s search engine. The main keywords used were “Completely Knocked Down”, “CKD”, “Knocked Down Production”. The search of CKD did not reach many results, however a combination of that and “automotive manufacturing” did bring some results related to the topic. For definitions, keywords such as “supply chain”, “lean production”, “value chain”, “globalisation”, “forecasting accuracy”, “global manufacturing network”, “lead times” and “quality management” have been investigated. Selection of articles has been based on their publication date (the more recent, the more relevance has been given to the source for this investigation). In addition to theories and previous research, real-life industry applications have been found.

The same keywords or combination of have been used for the different search engines. According to the title and relevance (date and content) of the selected study, the necessary information was searched for. Literature references have been used during the background research phase of the investigation and to establish a solid framework on which the analysis is based. The discussion and conclusions also refer to the theoretical framework.

2.4 Case study

A case study is defined as a study carried out by monitoring the phenomenon during a certain period or collecting information with respect to the development of the phenomenon during a certain period. (Swanborn, 2010) A case study is found to go hand in hand with qualitative research. (Yin, 2010) For this investigation, the lack of information available in the literature, made choosing to carry out a case study logical.

The case study was carried out at a Brazilian company mainly dealing with technology products within five main industry sectors: security, telecommunication, network, energy and access control. The study case was carried in the security department, to collect specific information and gain a complete overview of the supply chain of CKD products. This investigation deals specifically with CKD in the security business unit of the company. The products delivered by the security unit are mainly video cameras (CCTVs). Most of them are sourced as kits, which are totally assembled at Brazilian factories.

The reasons why the company adopts CKD arise due to its geographic, social and economic context. In Brazil, taxes on imported goods can add up to 70% of the final price. Up to 1990, Brazil was a closed market for import (Anon., 2017). Today, typically, the Brazilian government imposes a 60% tax calculated on the price of goods at their origin plus shipping costs and insurance on fright. The high tax on imported goods in Brazil is a result of the government control of the internal market and the strategy of protection of domestic production made to incentivize economic growth. These taxes on imported goods, draw many companies towards local production, incentivized by government aids. This information helps to understand the special market environment of the case study. It also highlights that enjoying tax incentives and lower overall logistics costs is the main driver among all industry sectors, in any country.

With the collected information, the overall benefits, the problems and areas for improvement are provided. The rationale behind using CKD as a strategy is also given throughout the investigation.

By observing and collecting real data at the company and comparing it and integrating it with the information found in the literature, knowledge on the topic was gained. The observations covered the main aspects of the supply chain, from the conception of the products and raw material sourcing to their final assembly. The case study focused on specific problems that the company needs to tackle with the aim of finding a general guideline for the reduction of waste and overall improvement of the processes. Observations were not the only way empirical data was collected at the company: interviews at various levels of the company structure have also been a useful source of data.
2.4.1 Observations

Observations were performed as part of the case study to gain an overview of the supply chain of Completely Knocked Down products. Observation of processes at different departments of the family sector of security helped to obtain relevant information for each supply chain stage. Spending 2-3 full work days at the company for 4 months provided enough to observe and to learn. Table 1 summarises the planning of the observation carried out at the company in different supply chain departments.

Table 1 Summary of Observations and planning

<table>
<thead>
<tr>
<th>Observations Summary</th>
<th>Method</th>
<th>Data collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Development</td>
<td>Direct observation; shadowing of R&amp;D engineer</td>
<td>How to integrate CKD from design phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Why to design for CKD (pros and cons)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Where are problems related with waste and how to avoid</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Direct observation; shadowing of purchaser of CKD; Access to BOM and internal purchasing practises</td>
<td>BOM of CKD products; difficulties in negotiation</td>
</tr>
<tr>
<td>Logistics</td>
<td>Direct observation; shadowing a logistics analyst</td>
<td>Order Placement process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Forecasting analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Order quantity Strategy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lead Times and risks</td>
</tr>
<tr>
<td>Quality</td>
<td>Analysis of data on inspections and audit at the supplier side; analysis of different procedures to tackle problems, how to solve them</td>
<td>How is quality inspection carried out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What are the consequences of rejected batches on the production</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How to avoid quality problems and plan for them</td>
</tr>
<tr>
<td>Import/Transportation</td>
<td>Information combined from Logistics and Purchasing</td>
<td>How are products transported from suppliers to final destination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What happens when a shipment is delayed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What are the available transportation modes</td>
</tr>
<tr>
<td>Visit to CKD Assembly plant</td>
<td>Shadowing of a quality engineering; seeing assembly process, carrying an audit</td>
<td>Assembly process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>How are quality error traced and tackled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>What are the most common errors and why Root cause analysis</td>
</tr>
</tbody>
</table>

Shadowing specialists for each observed supply chain stage was a very valuable way to understand in practice all the aspects of such a strategy and to comprehend its operations, the risks, the errors and the benefits and drawbacks. The observations were deepened and concluded by a week-long visit to the assembly plant specialised in CKD assembly, which provided very valuable information for the study. Direct observation of the processes provides an arbitrary overview of the supply chain of CKD products in the case study company.

2.4.2 Interviews

To integrate and complete the information collected individually and its critical interpretation, some insights about the processes from people internal to the company have been used. Interviews helped to gain knowledge from employers at different levels, to get to know their perception of CKD. During observations and shadowing, questions were asked, but formal interviews were scheduled to complete the information.

Interviews can fall between two main types: structured and unstructured (Yin, 2010). Adaptations of such methods can be used to adjust the collection of material to a specific situation. Because of the context where the interviews were carried and the sometimes sensitive subject for the company, a semi-structured approach was adopted. Semi-structured interviews follow a general guideline but the interviewer can follow the trajectory that best fits the situation.
and increases the amount of valuable information collected (Keller & Conradin, 2018). The data collected adds subjective and internal perspectives to the problems, how they are currently addressed and the possible solutions. By interviewing employers at different decision-making positions and different departments, reliability is ensured. The informal setting typical of a semi-structured interview facilitated the stream of information. The main drawback is that they are resource intensive and time-consuming interviews (Keller & Conradin, 2018).

The interviews were performed with a Supply Chain Manager, a Quality Engineer, a Product Developer; a Purchaser, a Logistics Analyst and a Product Manager. To reduce errors and making the interview comfortable and not too formal to the interviewed, the interview was voice-recorded and quick notes were taken about expressions and emotions during the interview. After the interview, the record was played and more extensive notes about answers have been taken and registered.

Table 2 summarises the interviews carried out. All the interviews were related to CKD products, thus, the topics addressed refer to that category.

**Table 2 Case study interviews**

<table>
<thead>
<tr>
<th>Role</th>
<th>Main topics addressed</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Developer</td>
<td>- CKD importance</td>
<td>1.30 hours</td>
</tr>
<tr>
<td></td>
<td>- CKD marketing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- CKD development</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Purchasing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Quality Problems</td>
<td></td>
</tr>
<tr>
<td>Purchaser</td>
<td>- Negotiation practices</td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>- Supplier relationships</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Internal KPIs of cost reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Quality problems</td>
<td></td>
</tr>
<tr>
<td>Quality Engineer</td>
<td>- Cost reduction</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>- Waste generation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Scrap accumulation and how to manage it</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Design problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Importance of supplier relationship</td>
<td></td>
</tr>
<tr>
<td>Supply Chain Manager</td>
<td>- Importance of CKD production</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>- Main problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Logistics costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Improvement and lean procedures</td>
<td></td>
</tr>
<tr>
<td>Product Manager</td>
<td>- Relationship with suppliers</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>- Internal communication issues</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Impact of delays in the delivery of product</td>
<td></td>
</tr>
<tr>
<td>Logistics Analyst</td>
<td>- Forecast analysis</td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>- Supply chain management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Lead times</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Sudden changes in demand</td>
<td></td>
</tr>
</tbody>
</table>
2.5 Data analysis

To achieve the purpose of this investigation, and to ensure collection of arbitrary data accurate analysis of data was carried. The analysis of data is difficult to separate to its collection since it is difficult not to analyse simultaneously the collected data. The analysis needs to be continuous. The interpretation of the data is described in the conclusion of the study. By first collecting a good amount of information, then breaking it down in order to identify patterns, some generalisation can be made and a framework can be designed.

2.6 Reliability and Validity

The study has carried out ensuring validity and reliability. Because the aim is to provide the industry and researchers with information about the little investigated topic of CKD, validity and reliability are essential for the study to be used for further research or as a framework for industries. Avoiding personal assumption or wrong information were important factors for the sake of the study. By collecting information through interviewing different people, more objectiveness in the result was ensured. According to Yin (2014), there are four criteria for rigorous case studies, all of which this investigation provides security for:

1. Internal Validity, referring to the causal relationship between variables and results. Targeting a specific area of the production sectors of the company chosen for the case study (security line) and assess the CKD supply chain and costs, helped a valid collection of data which has been compared to available data from previous research and current CKD uses in different industries. Additionally, by observing continuously during the time at the company, and through interviews carried out with different people, the findings can be said to be arbitrary. The relationship between variables (cost and waste) could be directly seen during and after the case study. Especially during the interviews, the main problems highlighted were found a solution for in the results (the frameworks)

2. Construct validity, relating to the fit of the set of measurements and objectives. In this study this is reached by triangulating different theoretical sources from various industrial fields. In the case study, changing periodically departments, but focusing on the same area of products (security video-cameras), helped following throughout the entire supply chain of such products, the problems observed and confirm the observations and the results from the interview.

3. External Validity, referring to the ability to draw general conclusions applicable to other cases was achieved by cross-comparing different industry fields and their data. In this study, this has been part of the final objective. To develop a framework applicable across industries, using the information collected during the case study was possible through the combination of the case study, which allowed practical knowledge and a deep study of the little available knowledge on CKD production as well as the study of existing frameworks to use as an inspiration.

4. Reliability, which deals with the ability to repeat the study in the future and achieve the same result. It relates to how credible a measurement method is (Byrman & Bell, 2007). This investigation secures it through the combination of all the aforementioned criteria.
3 Theoretical Framework

This section starts with an overview of the situation, which leads to some important definitions, literature review and examples from other industries.

3.1 Connection between Theory and RQs

To assist the achievement of the purpose, a thorough theoretical framework, addressing the important points and the existing theories is essential. The theories, definition and knowledge presented in this chapter constitute the base for the analysis of the results and the conclusions.

Figure 5 is a diagram visualising the connections between the theory and the research questions addressed.

As illustrated, each question is backed by different theories, however, the theme of lean production and value creation are recurring. Lean production philosophy, its concept of waste elimination and value creation, are aligned with the purpose of this investigation and constitute the base on which the purpose is achieved. Below are definitions and theories.
3.2 Concepts and Definitions

This chapter introduces the important definitions and concepts on which the thesis is based. Definitions of Knocked Down types of production and their distinction and the definitions of important concepts on which the discussions and conclusions are developed are included in the subsection below.

3.2.1 Completely Knocked Down production

After outlining the contexts which a company can be part of, it is important to fully understand the concept of CKD, its advantages and limitations. Parts production within a Knocked Down strategy can be carried out by different methods:

- CKD (Complete Knocked Down); the product is exported as a conglomeration of its component parts. It is shipped as a completely disassembled product (parts) and assembled at the factory of the country of destination.
- SKD (Semi Knocked Down); the kit presents some already assembled components carried out at the original factory. Usually, the choice depends on the technology and skills available at the manufacturing and final plants and the costs involved.
- MKD (Medium Knocked Down); the middle ground of KD approach.

(Schwede, et al., s.d.)

CKD is characterised by a minimum level of assembly at destination, reducing investment for specific machinery, installations, technology and skills at the buyer side. Usually, electronic components arrive assembled on PCB boards for SKD products. On the other hand, CKD involves the production of parts to be exported and sent for assembly at the final factory. The level of assembly at the final factory, in this case, is more complex. Commonly, a CKD exporter has the control of technology know-how and dominates the structure and information flow in the factory. The importer receives the kits which are unpacked and assembled according to instructions (Schwede, et al., s.d.). Generally, the manufacturer designs the kits. The final producer is supposed to choose among the products listed in the catalogue handed by the manufacturer.

CKD supply chains need to be carefully managed, at every stage. The several months spent travelling, the frequent handling and various weather and temperature conditions might affect the quality of the parts delivered, making packaging of primary importance. The modules should be made to easily transportable (Arbós, 2012). Packaging costs increase for CKD products, because of component-specific packages and individual packaging for some parts.

KD supply chains enable Original Equipment Manufacturers (OEM) to entry emerging markets despite restrictions, high customs, insufficient supplier base and low qualification level (Erfurth & Bendul, 2018). Furthermore, CKD production allows companies in developing markets to gain experience in a particular industry, and exporters can access new markets (Freitas, et al., 2017). Typically, CKD or SKD production in the automotive electronics industries are used to enter new or protected markets (Schwede, et al., s.d.). It is a strategy which both suppliers and manufacturers can benefit from. In Brazil and India for example, trade liberalisation and changes in some industry policies the industry structure to adapt accordingly and increased Foreign Direct Investment (FDI); additionally, logistics cost and protectionism made local or regional production of many items a necessity. (Humphrey, 1999).

Performance and stability of the KD supply chains are crucial, with core tasks being the timely delivery of all the kit components and compliance with market entry restrictions (Erfurth & Bendul, 2018). The possibility to transport these products as unfinished reduces costs, tariffs and taxes.

3.2.2 Globalisation

Fierce competition in a rapidly changing global market imposes manufacturing companies to transform and adjust their supply chains abroad (Feng & Wu, 2009). Adding value, minimising costs and production time, ensuring quality and reliability are the typical challenges of supply chain management.
Supply chain management aims to coordinate the flow of materials and information along the supply chain. By reducing the number of suppliers, achieving smaller inventories, lowering costs, production lead time and increasing market response, supply chain management seeks to find the best practice (Freitas, et al., 2017).

Pursuing low-cost country sourcing is becoming a less popular trend compared to some years ago (Ludwig, 2011), due to the rise of total logistics cost analysis approach. Lowest cost purchasing is no longer a priority. Companies are now looking for specific expertise, regional development and logistics efficiency. Nowadays, the choice of building vs buying and where is no longer driven by costs only. Factors such as total logistics costs, risks, obsolescence, quality issues, taxes, closeness to customer base, adaptability, customisation, agility are rising in importance (Ludwig, 2011).

Within the context of globalisation, Global Manufacturing Networks (GMN) are manufacturing systems based on modern information and communication technologies that integrate firms with different capabilities to create value (Wu, et al., 2006). In global logistics, geographical location of a plant and its advantages (low-cost manufacturing, low-cost resources, access to skills and technology, proximity to suppliers, duties and tariffs) should be considered together with the level of site competence and organizational capabilities. The disadvantages (integration, communication, distance) should be compensated for. Today, a company’s ability to adapt to market changes determines its success or failure (Golzer, et al., 2014). Depending on the motivation that drives global production, companies choose specific strategies for global networks. CKD production makes sense in restricted market access or with high customs duties (Abele, et al., 2008).

The trend of customisation made it necessary for manufacturers to adopt a more integrated, solution-based service (Wu, et al., 2006), which is what GMNs seek to provide companies with. The rise of specialised manufacturing, new information and communication technologies provide benefits for global corporations. It allows them to establish relationships with the actors in the supply chain, improve communication, data information sharing, transparency and visibility. There are challenges in adopting a GMN. The main ones being the ability to access all relevant data, which should be reliable and valid; and the effective analysis, usage, validation and comparison of the resulting massive amount of data (Golzer, et al., 2014).

The value chain describes the full range of activities, tangible and intangible that firms and workers perform to bring a product from its conception to end use and beyond (Gereffi & Fernandez-Stark, 2016), (Bamber, et al., 2017). By focusing on delivering value, through the avoidance of all unnecessary activities, efficiency and effectiveness can be achieved, thus problems of visibility, waste and cost be eradicated. Due to many uncontrollable variables involved in global supply chains, complexity is high. Dependency on suppliers or customers should be avoided. It goes against the building of an effecting Global Network and raises problems of flexibility, among others.

A balanced supply chain requires trade-offs within the value stream. The trade-offs mainly happen around the following basic functional activities in the value stream, with the ideal situation outlined in brackets:

- Procurement (maximum purchasing discounts)
- Inbound Logistics (minimum transportation costs)
- Operations (low production costs and high-quality products)
- Marketing and Sales (wide product range and high availability)
- Outbound Logistics (high flexibility and reactiveness to market changes)

Adapted from (Mason-Jones & Towill, 1999).

Today, standardised mass-production is becoming increasingly challenging due to the rise in customisation. As previously stated, the drives for outsourcing are changing. Collection of customer information, the need for diversified production, for multitasking and creativity within the workforce make “classic” globalisation practices almost obsolete (Jovanova, 2017).
At heart of localisation, there is protection and rebuilding of local economies, without restricting the flow of information, technology, management and legal structures (Colin, 2013). Basic steps to help local economies to thrive, involve the reintroduction of tariffs and quotas for domestic economies; introduction of taxes to fund local production and the reorientation of end goals of trade (Colin, 2013). CKD manufacturing is a way to produce locally while sourcing globally. The term glocalisation refers to globalisation and localisation not being in antithesis in a global network. Rather, it is about the global integration of markets while recognising local identity and specific competencies (Wiegerling, 2004).

### 3.2.3 Transaction Cost Economics

Transaction Cost Economics is another method to help taking decisions about global supply chains. TCE analyses whether to keep or outsource a process based on the transaction costs between organizations. It takes a process-oriented perspective and enables a connection between KD supply chains and GMNs. TCE can be employed to allocate value-adding activities between the overseas and the headquarters (Erfurth & Bendul, 2018). Transaction costs include coordination costs and transaction risks. The first represents the cost of exchanging information and incorporating it into the decision process; the latter are the costs rising from risks shared with the other party (Grover & Malhotra, 2003).

Three dimensions drive transaction costs:

- Uncertainty; sudden and unplanned changes within the transaction, caused by market fluctuations.
- Infrequency; referring to the rate of reoccurrence of the transaction, depending on market demand fluctuations and planning.
- Asset specificity; the ability to provide appropriate assets supporting the transaction.

(Erfurth & Bendul, 2018).

The number of available suppliers for a specific product and the loss of resource control (Grover & Malhotra, 2003) are transaction risks to be prioritised to avoid dependency and flexibility issues. Focusing on long-term relationship with suppliers, monitoring their performance, and jointly addressing problems, is a solution. TCE helps in evaluating the relationships between buyers and suppliers and clarifies the value of developing long-lasting partnerships (Grover & Malhotra, 2003). Also, it can be used to evaluate enterprise logistics and other coordination mechanisms.

### 3.2.4 Waste in Lean Supply Chains

Lean supply chain (LSC) can be defined as a set of organizations directly linked by upstream and downstream flows of products, services, information and funds that collaboratively work to reduce cost and waste by efficiently pulling what is needed to meet the needs of customers (Tortorella, et al., 2017). Lean production systems refer to learning organisations oriented towards continuous improvement. They aim is reducing unnecessary variations and steps in the work process by elimination of waste, considered as anything that does not add value to the final product or service to be delivered (Mrugalska & Wyrwicka, 2017).

Lean operations focus on customer value and managing the value chain to avoid errors, develop the capability for flow production and reach “zero waste” (Hines, et al., 2004). Establishing long term relationship with suppliers and measure output criteria such as quality, cost and delivery, are important to reach a smooth workflow and improve performance (Hines, et al., 2004). Lean procurement is about long-term partnership with fewer suppliers and less reliance on low-cost bidding (Myerson, 2012). Keeping inventory levels stable with demand and maintain a stable production schedule (Ludwig, 2011) are other challenges to overcome. Meeting regularly with suppliers to manage capacity around material shortages and update forecast schedules help to ensure a stable material flow.
Lean Supply Chain aids the switch from profit targets as main drivers, towards a strategy based on long term view and planning (Tortorella, et al., 2017). According to Nicoletti, lean should be the “mean”, not an objective (Nicoletti, 2018). In this study, it is the mean that aids the improvement of CKD supply chain.

Waste is defined as everything that does not add value to the process. It leads to uncertainty, unnecessary costs and time loss. Lean philosophy recognises 8 types of waste:

- **Overproduction;** referring to producing more items than customers’ demand.
- **Over-processing;** resulting from products not conforming to requirements. It relates to quality and translates in additional processing for the product before completion.
- **Defects;** include scraps, reworks and can lead to overproduction and over-processing.
- **Waiting;** referring to products or materials sitting idle, waiting to be used. It generates excess inventory and accumulates disorder in the production facility.
- **Excess Inventory;** resulting from poor inventory levels planning and forecasting errors. The ideal should be having a minimum amount of safety stock while ensuring flexibility and reliability.
- **Transportation;** moving products costs money without adding value to the product since no changes happen at this phase. The aim is to minimise risks and resources at this stage.
- **Motion;** excess motion by either machine or human can negatively affect quality.
- **Under-utilised talent;** employees make up the company. Continuous improvement and problem-solving should come from those who daily deal with the problems.

The total performance metric for customer value is defined by the following equation:

\[
\text{total value} = \frac{\text{quality} \times \text{service level}}{\text{costs} \times \text{lead time}}
\]

The equation clarifies that improving one performance is of no worth when it happens at the expense of worsening another (Mason-Jones, et al., 2000).

In a global supply chain, time and transportations increase. Lead time is the time elapsed from customer order until delivery to the final customer (Vaughan, 2011). In lean manufacturing, lead time needs to be minimised to enable an agile supply chain, responsive to changes in the market and adaptable for the best practice. The Total Cycle Time Compression Paradigm is the minimisation of the elapsed time between customer enquiry and customer need being met (Mason-Jones & Towill, 1999). Minimisation can be reached by predicting, monitoring and systematically seeking to reduce cycle time. By focusing on identifying the value adding activities and eliminating those that do not add value, the overall lead time can be significantly reduced.

Another way to reduce waste, therefore cost is to ensure quality from the start. Getting quality right the first time is a pillar of lean thinking philosophy. Toyota calls the waste generated from quality error, “the cost of poor quality, which arises from non-conformity or inability to meet quality standards and has introduced the concept of TQM (Total Quality Management) to avoid it (Chiarini, 2012).

Quality assurance practises are defined as *activities and attitudes that promote collective involvement to work together in a process of continuous improvement and product or service quality deliver* (Bayo-Moriones, et al., 2011).

To improve internal operations, adopting certifications such as ISO 9000 helps meeting some specification, but is not enough. Internal monitoring of suppliers and frequent benchmarking promote good quality levels. External practices are mainly focused on information sharing, trust, commitment, collaboration and proactiveness in the relationship between buyers and suppliers. TQM preaches that quality should not be “inspected”, but secured within the processes (Lee & Whang, 2005). According to Deming if quality is improved through inspections, as quality standards rise, inspection frequency increases accordingly, which consequently results in higher costs. Higher quality should not result in higher costs. Quality can be assured through strict process and statistical control; prevention (through poka-yoke, the design of processes and products enabling direct identification of defects and problems);
and design for quality (Lee & Whang, 2005). Commitment to quality should drive a company’s strategy.

### 3.2.5 Forecasting accuracy

Understanding current and future demand is essential for planning. According to Meyerson, all forecasts are wrong (Myerson, 2012), but by targeting and limiting variability, companies can minimise errors in their forecast. Time series and linear regression give a good statistical baseline. Big data analytics can come of great help in this field. However, organisations need to go beyond data collection and use day-to-day mining operations of real-time data to improve decisions (Nicoletti, 2018). Forecasts are based on a combination of inputs: projection of historical demand data, advanced orders, corporate demand plans and market intelligence (Kempf, et al., 2011).

Waste that occurs in forecasting is commonly caused by budgeted forecasts; using sales data rather than demand or order data, and lack of communication within the company. The increasing supply chain complexity requires significant intervention in the management of process and information, both internally and intra-organizations (Nicoletti, 2018). Many production planning systems do not plan for uncertainty and no effort is spent recognising uncertainty sources (Kempf, et al., 2011). Generally, the most common tactics used to reduce the impact of uncertainty are: safety stocks; re-planning; time fences; frozen schedules; flexible capacity; backlog management and inflated planned lead times. Frequent routine tracking and measurement of uncertainty are required to control and minimise waste generated from errors and delays in the production (Kempf, et al., 2011).

### 3.2.6 Relationship with suppliers

A good relationship and clear communication with suppliers can help keep better track of the supply chain. Sourcing deals with purchasing products and services outside the organisation according to the strategic plan and the organisation’s objectives (Nicoletti, 2018). Sourcing decision drivers are changing: from being mainly price-based considering quality and volumes, today the priorities are responsiveness and service level (Vaughan, 2011). Sourcing is moving to markets closer to the customer base. Companies need to develop more of a single partnership with suppliers, considering total logistics cost (Myerson, 2012). Supplier partnerships and strategic alliances refer to co-operative and exclusive relationships with the objective of reducing uncertainty and enhancing control of the supply chain, as well as to increase financial and operational performance. The suppliers’ ability to meet the organization’s long term needs should be periodically evaluated (Gunasekaran, et al., 2004).

Visibility on all nodes of the value network (Nicoletti, 2018) is necessary to prevent disruptions and can reduce overall costs of procurement, decrease stocks, improve service levels, achieve higher levels of integration and manage complexity. Efficiency in the relationship between buyer and supplier is associated with management commitment, collaboration and inter/intra-organisational dimensions (Bayo-Moriones, et al., 2011).

### 3.3 Existing frameworks of reference

_In order to come up with waste and cost minimisation guidelines and improve CKD supply chains, some existing frameworks have been used as inspiration, provided in this subsection._

#### 3.3.1 DMAIC

The Define, Measure, Analyse, Improve and Control (DMAIC) procedure is a rigorous method to remove wastes which promotes continuous improvement. It is a data-driven quality strategy (ASQ The Global Voice of Quality, 2019) made of five phases, summarised as follows:

1. **Define** the problem, improvement activity, opportunity for improvement, goals and customer requirements;
2. **Measure** performance through:
   - Activities process mapping
   - Capability analysis to assess ability to meet specifications
   - Pareto Charts to analyse frequency or causes of problems

3. **Analyse** the process to determine root causes of variation and poor performance through:
   - Root cause analysis
   - Failure mode and effects analysis (FMEA)

4. **Improve** process performance by addressing and eliminating root causes:
   - Design of experiments to solve problems
   - Kaizen event to introduce rapid change and using employees’ ideas

5. **Control** the improved process and future performance using:
   - Statistical Process Control (SPC)
   - 5S
   - Mistake proofing (poka-yoke) to make errors impossible or immediately detectable

Adapted from *(ASQ The Global Voice of Quality, 2019)*

![General DIMAIC process](image)

### 3.3.2 Waste Identification

Many waste identification tools can be used to detect non-value adding activities. The framework of reference in this study is summarised by the diagram below, adapted from *(Mostafa, et al., 2015)*.
The 3 phases identified in the framework are:

1. Waste documentation; referring to identification of customer value lays and the distinction between value-adding activities and non-value adding ones.
2. Waste Analysis; usually through Root Cause Analysis or cause-effect diagrams.
3. Waste Removal; using different tools available according to the situation. Failure Mode and Effect Analysis (FMEA), can help the prioritisation process.

Prioritisation through waste priority number (WPN) is given by the following formula,

\[
WPN = \sum Cost\ of\ Removing\ Cause + \sum Ease\ of\ Removing\ Cause + RPN;
\]

where RPN is the risk priority number found through;

\[
RPN = Impact\ of\ cause \times Occurrence\ of\ Cause \times Detection\ of\ Cause.
\]

Table 3 provides a legend summarising how to assess the various elements of the equation.
According to the prioritised waste to be removed, appropriate removal tools are selected.

### 3.3.3 Supply Chain Performance Metrics

The following framework for performance measures and metrics is divided into the 3 managerial levels at which measures should be taken. It represents a general guideline for actions to take that needs to be adapted according to each specific industry context. This framework reached a similar aim to the one purposed in this investigation, which is to come up with a general framework of best practices.

#### Table 3 Legend for Waste Prioritisation Number

<table>
<thead>
<tr>
<th>Description</th>
<th>Severity of Cause</th>
<th>Occurrence of Cause</th>
<th>Detection of Cause</th>
<th>Cost of Removal</th>
<th>Ease of Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Score</td>
<td>Very High impact: 10</td>
<td>Always: 10</td>
<td>Very difficult: 1</td>
<td>High cost: 10</td>
<td>Easy: 10</td>
</tr>
<tr>
<td>Medium Score</td>
<td>Moderate or significant: 5</td>
<td>Medium: 5</td>
<td>Medium: 5</td>
<td>Medium: 5</td>
<td>Medium: 5</td>
</tr>
<tr>
<td>Low Score</td>
<td>Very Low or none: 1</td>
<td>Very unlikely: 1</td>
<td>Very Easy: 1</td>
<td>Low Cost: 1</td>
<td>Difficult: 1</td>
</tr>
</tbody>
</table>

#### Supply Chain Performance Metrics

<table>
<thead>
<tr>
<th>Strategic</th>
<th>Tactical</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan</strong></td>
<td><strong>Tactical</strong></td>
<td><strong>Operational</strong></td>
</tr>
<tr>
<td>Customer perceived value; Lead Times; Net profit VS Productivity; Cash flow.</td>
<td>Product Development time; Forecasting Accuracy; Productivity; Order Placement Methods.</td>
<td>Defects; Productivity; Cost per operation hour</td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>Supplier Delivery Performance; Supplier Lead Time Against industry norm; Supplier Pricing VS Market; Efficiency</td>
<td>Percentage of defects; Capacity utilisation.</td>
</tr>
<tr>
<td><strong>Make/Assemble</strong></td>
<td>Range of products and services</td>
<td>% of total defects; % of on-time delivery; Efficiency of deliveries; % of critical deliveries.</td>
</tr>
<tr>
<td><strong>Delivery</strong></td>
<td>Flexibility; Effectiveness of planning schedule</td>
<td>Meeting of customer needs; Effectiveness of distribution planning; Effectiveness of delivery; Percentage of in-transit goods; Delivery reliability.</td>
</tr>
</tbody>
</table>
3.4 Literature Review

There are no established legal definitions of CKD (World Trade Organization, 2009), but it is becoming increasingly common for companies to adopt it. According to literature, KD production offers good control levels and the opportunity for a company to make effective use of local resources while minimising investment (Tomiyama, 2014). To facilitate exchanges within the complex network of a global supply chain, where the engineering phase is carried somewhere, raw materials come from different countries and the assembly is made at factories around the world, companies need to develop networks of international logistics centres that collect, consolidate and package parts for export (Ludwig, 2011). An extensive total logistics cost analysis must be put in place, to keep track of the flows, cost and solutions, and to come up with the most cost-effective strategy. If customs duties are high and there are restrictions on market access, CKD is one way to produce locally at a competitive cost. Even though variable production costs are higher, CKD significantly reduces fixed costs (Eberhard, et al., 2008).

To facilitate exchanges within the complex network of a global supply chain, where the engineering phase is carried somewhere, raw materials come from different countries and the assembly is made at factories around the world, companies need to develop networks of international logistics centres that collect, consolidate and package parts for export (Ludwig, 2011). An extensive total logistics cost analysis must be put in place, to keep track of the flows, cost and solutions, and to come up with the most cost-effective strategy. If customs duties are high and there are restrictions on market access, CKD is one way to produce locally at a competitive cost. Even though variable production costs are higher, CKD significantly reduces fixed costs (Eberhard, et al., 2008). In recent years supply concepts such as completely knocked down and part-by-part (PBP) have been applied to supply newly established production sites in markets with improving purchasing power (Schwede, et al., s.d.).

3.4.1 Packaging solutions for CKD

As previously stated, packaging is crucial to CKD operations, since the products move through longer supply chains and are often more difficult to pack efficiently than regular parts. Heating or cooling at the plant, as well as the choice of cardboard or wood are essential decisions to be taken to ensure quality (Coia, 2012). The additional costs for CKD packing and CKD unpacking have to be taken into account when designing the supply chain (Schwede, et al., s.d.). Packaging pricing is considered to be about 30% lower in China than in other Western countries, however spending less in Chinese packaging could be offset by the benefits of sourcing locally, reducing obsolesce risks and transportation costs and improving service level and flexibility (Vaughan, 2011).

3.4.2 Logistics cost of CKD

Literature also provides with a formula to calculate the overall logistics cost of CKD:

\[
\text{Cost of CKD} = \text{cost of stock} + \text{cost warehouse} + \text{cost customer clearance} + \\
\text{cost shipping} + \text{cost customer clearance (supplier)} + \text{cost stock (supplier)} \\
+ \text{cost of packing (supplier)} + \text{cost of unpacking}
\]

Each cost variable is summarised as follows:

- Cost of stock (country) = \( \sum_{\text{part}} \text{holding cost (part, country)} + \text{rent (country)} \)
- Holding cost (part, country) = avg stock (part, country) * val (part) * interest rate (country)
- Rent = max(\( \sum_{\text{part}} \text{stock (part, t, country)} \times \text{size (part)} \times \text{rentsqm} \text{(country)})
- Customer clearance cost = #ships * clearance taxes (country)
- Shipping cost = #containers * container fee
- Cost of warehouse = #container * cpacking (country) + \( \sum \text{holding cost (part, country)} + \text{rent (country)} \)

Adapted from (Bokor, 2012).

The assumption in this calculation method is that there no change in currency rate. This can be used to get a general sense of the overall costs involved in the supply chain and to aid the decision of undertaking a particular strategy.
3.5 Examples from the industry

As stated in the delimitations, not much information about the current uses of CKD was available. The industry sector which provides most information is the automotive industry. As a method of vehicle assembly, the complete knockdown system (CKD) is growing as a means of manufacturing, particularly as an initial production system in developing markets (Coia, 2012).

3.5.1 Automotive industry

The variety in automotive production requires flexibility, optimal sequencing and individual allocation of parts and components. Due to the acceleration of globalisation and the saturation of the traditional automotive markets, Original Equipment Manufacturers (OEMs) have shifted their focus to less mobilised markets and established plants in overseas markets and created global manufacturing networks (Erfurth & Bendul, 2018). To secure high-quality products and stable supply, OEMs have employed cost intensive knocked down supply chains to ship all parts arranged in a kit (Erfurth & Bendul, 2018). Historically, automakers used under-utilized facilities or contract manufacturers to assemble CKD kits, allowing them to forego direct investment while having vehicles locally assembled. Chrysler, for example, uses local contract manufacturers to assemble Jeep Cherokees in Austria, Indonesia and Malaysia and contracts with Volvo, Honda and Daihatsu in Thailand (Sturgeon & Florida, 2000). The most popular approach to reduce risks is to establish CKD assembly facilities. CKD plants can drive training, supplier development and logistics in new locations. Profits with CKD can be made by effectively manage their supply chain. CKD is one of the possible forms of technology transfer and delivery of products between countries, which falls within one of the four specific strategies of internationalisation of the automotive industry, which are: Completely Built Up (CBU, the export of finished cars); SKD; CKD; and integrated local manufacturing (Cavalcante & Araujo, 2015). CKD offers the benefit to customise final products to the specific market they are intended to.

Examples from the automotive industry show that the existence of a medium/long term relationship established between the assembler and the supplier of CKD determines a good flow of materials. Following a strategy of standardised packaging of CKD as opposed to more customised one, is found to reduce cost of the transported materials, further reduced by economy of scale (Cavalcante & Araujo, 2015). Problems with this strategy are linked to the tight planning schedule of operations, volumes and stock levels. These problems could be managed by a combination of the tools and strategies provided by lean production systems and the creation of value chains (Freitas, et al., 2017), outlined previously.

The rationale for CKD could be explained by some practical examples. For instance, during the 1970s, the Philippines imposed local content requirements to participants in a “progressive car manufacturing programme”, to move up from the import and assemble pattern of industrial development experienced during the 50s and 60s (Ofreneo, 2008). Before and after the Second World War, the Philippines imported completely built-up units (CBUs) of cars mainly from the United States, until their ban. The production, therefore, moved to CKD/SKD assembly. The government imposed some conditions on the local content of the assembled car for car manufacturers to be able to continue with CKD/SKD strategy. Import restrictions were eliminated during the 1980s, tariffs reduced, which increased the sourcing of CKD packages (Ofreneo, 2008). Similarly, the Russian Government adopted a policy that made foreign automotive industry shift from SKD to CKD production in order to modernise Russia’s automotive industry (Tomiyama, 2014). Many developing countries where CKD is thriving followed similar processes, among them Brazil.
4 Findings

This section provides an overview of the empirical data collected. This data is used to answer the research questions formulated in section 1.

4.1 Observations

This subsection presents the information gathered during the case study, including an exhaustive description of the context of the company and the supply chain stages observed, together with the summarised information collected from the interviews.

4.1.1 Production Development

A team of engineers carries out the design of a new product or a new version of an existing product. Several tests are carried out in this phase to ensure good functioning. The products are first tested in the laboratory. After passing this stage, there is the users’ test. Design includes measurement specifications and the decision on the materials to be used. The design is usually adapted according to the supplier offer. Suppliers already have catalogues for CKDs they supply, whose final design can be twisted to fit the market requirements and specifications. Minimising changes from the supplier version at this stage brings considerable advantages. The engineering work, the testing of parts and the homologation are reduced (Humphrey, 1999). However, products require customisation, and adaptation is necessary to fit with different climate conditions, customer needs and technology. Engineers also deal with quality issues, when quality problems arise during assembly, they try to find design solutions. Early intervention and collaboration between suppliers and Research and Development (R&D) starting from design are essential to reduce waste, minimise quality problems and improve the overall supply chain. Effective intervention can only be possible in an environment of transparency and integration. A team of Chinese engineers from the main suppliers are in the headquarters to help with any problem arising.

4.1.2 Purchasing

Generally, purchase of complete knocked down kits is more expensive than buying the final product directly from the Original Equipment Manufacturer (OEM). The price is higher due to higher packaging costs that arise from the need for individual packaging, determined by specific handling and quality requirements. The case study company mainly sources from China. For Chinese suppliers, it costs more to deliver a disassembled kit that a finalised product. This results from Chinese government monetary incentives to local companies that export complete products abroad. When delivering disassembled parts, the Chinese supplier would not receive any incentives, increasing the final price of the parts. Choosing CKD results from the opportunity of tax deduction that the Brazilian government offers to companies supporting local economy through the creation of jobs for local workers. Assembling locally CKD kits is an excellent and cost-efficient way to obtain the incentive. For the case company (but it applies generally), purchasing SKD kits is actually cheaper than for CKD, because it requires less work to be done at the factory of destination. However, Brazilian government placed restrictions on the volume of SKD import. CKD is, therefore, the most popular production strategy and the focus of this investigation.

Purchasing CKD follows the same procedure of any other product or raw material ordered. The purchasing team receives specifications from R&D. Suppliers are approached with the exact specifications and negotiation is initiated. Due to the relatively low number of suppliers available for CKD and the need for customisation and follow-ups, the relationship between the company and its CKD main supplier is closer than it is with raw material suppliers for other products produced at the company. The case study company currently relies on 5 suppliers for CKD. Among them, only one of them is the “principal”. With this supplier, there is better information integration and recently increased visibility and clear information sharing. The
error percentage from the main supplier is higher due to the bigger volume but, in the cases, it is a problem that falls under their responsibility, it is easier to find appropriate solutions. The negotiation generally happens by email. The explosion of the BOM of the order is made internally accessible through the company system. The presents some errors. It is sometimes outdated or it presents incorrect information on the parts numbers. This generates errors and delays. Due to the constant pressure on reducing price promoted by the internal KPIs, it can be sometimes difficult for the team to reach good deals. Trying to push order prices down results in rising the ordered volume, and consequently on increased quality issues and higher inventory costs as well as increased scrap.

4.1.3 Logistics

The Purchase Orders are placed by the logistics team, after negotiation and after checking stock levels registered in the system. Due to the long lead time (approximately 120 days), the order placement has to be carefully planned. The practices to reduce risks mentioned in section 3, such as increased frequency of orders, are not practically available to the company, due to the long lead time and high transportation costs. For this reason, purchasing in high volumes at low cost is considered advantageous. However, it is a double-sided sword: it could either result in accumulated inventory, increasing holding costs, or delays in the production in case the shipment does not arrive on time or presents quality problems.

The orders of CKD kits are placed once the stock levels reach the Economic Order Quantity (EOQ). To manage the supply chain at best, the company organises monthly meetings, where next period’s forecasts are discussed. Analysis of current stocks and needs follows, having defined the production plan. POs are placed once the plan is secured. Placing the orders is a necessary but risky action. The forecast needs to be the most accurate possible to ensure competitive tariffs and reduce delays at the factory. International parts ordering and forecast is a different process compared to what happens for local or regional companies. An international order is a forecast in itself, because of the long lead time between order placement and arrival. A forecast is the sales’ department guess about how many parts of that product the company will need in some months, which sometimes (for example with new products), is very hard to come up with. Recently, the company approved the proposal of increasing the minimum order quantity (MOQ) from 3K to 5K and 10K. This strategic decision has led to cost reduction per Purchase Order up to 60%. However, it carries several risks.

4.1.4 Quality

Inspections of CKD kits are carried out by the company directly at the supplier side, on arrival at the factory for assembly, during the assembly process and at the final stage, before delivery. The number of batches inspected is based on the standardised AQL (Acceptance Quality Level) table. According to the order quantity and its criticality level, a specific number of batches will be inspected. Depending on the product and the supplier, the acceptance rate varies. Inspections follow written guidelines and standardised checklists. There are some standardised procedures according to the situation. The inspection checklist includes visual messages and pictures to help the analyst compare the situation and correctly assess quality. The inspection is scheduled by the supplier through an inspection booking form. An inspection can give three different outcomes: “conform”, “non-conform” or “reservation”. Each inspection is registered through a form, complete of picture and specifications. A “reservation” status often results from changes in some product components. Due to the lack of method in updating the BOM in the organization’s system, it can be hard to identify the item, causing major delay and confusion. The long lead times (60 days from order placement to end of manufacturing and other 60 days for shipping), result in many risks difficult to predict or plan for.

If the inspection results “reserve” or non-conform status, the procedure includes other activities. According to the urgency of the shipment, some orders can be “conditionally approved” or “approved with restriction”. This happens when there is a detected problem that will not directly affect the final client (for example a change in the raw material supplier, but which needs to be solved quickly). In case problems are detected to be originated at the supplier side, 8D process is initiated. 8D is a structured methodology for problem-solving which includes the detection of the problem, the definition of the root cause, corrective action, permanent corrective actions and follow-ups. The company takes several actions to ensure
quality at the supplier side, including continuous re-assessment and periodic visits at the site. This does not solve quality issues that can be found at different stages in the destination factory. Each line has its quality control check, but at the final audit, the most critical stage, problems are still being found. At the destination factory, an incoming inspection is also carried out. The defect levels accepted is within 0.8% on average. There is a need to strictly ensure quality during assembly. Problems are found in terms of machine maintenance, lack of method, and handling from operators. Methods on training and the commitment from supervisors to follow procedures and follow-ups need to be ensured.

4.1.5 Assembly and Distribution

To benefit from governmental incentives, the majority of CKD assembly is carried at a factory in Manaus. Manaus is a Free-Trade Zone, which constitutes an additional factor which the company takes advantage of. A free-trade zone is defined as *an area within which goods may be landed, handled, manufactured or reconfigured, and reexported without the intervention of the customs authorities* (Encyclopaedia Britanica, 2016). Being a major area relatively underdeveloped, the government further incentives companies to produce there. Because of its economic and social conditions, generally low levels of technological development and operators specialisation are available. This comes handy to a company following a CKD or SKD strategy, which requires little technology and follows standardised procedures. However, it can result in quality problems.

The available means of distribution are mainly shipping and air freight. The first one is the preferred options since it secures lower transportation costs. It carries the most risks since it heavily extends the lead time. Quality problems resulting from transportation handling rarely occur.

4.1.6 Scrap and Lead Time

To ensure continuous improvement, the management team periodically sets and updates KPIs. Yearly annual cost reduction is one of the key objectives for everyone at the company, especially purchasing. Through observations and interviews, it became clear that scrap and long lead times constitute the main problems. Scrap result from incomplete kits, the building up in inventory levels of some components and from quality issues. Scraps can be found very late in the production line, at the final inspection of the assembled product. According to the stage where scrap is found, ways to deal with it varies. The further along the supply chain, the higher the costs. Scrap also generates because some smaller components of the kits are purchased in units, one unit containing more components than those needed for one product. For instance, the electronic circuits that have to be sealed to the Printed Circuit Board (PCB) through Surface Mount Technology (SMT). The circuits are sold in rolls which cannot be “manually cut” to be used somewhere else since that would negatively affect their quality and impair their functionality. The electronic components are very fragile and need to be carefully handled. Costly machinery is used to seal and cut the circuits. At the end of the supply chain, many surplus circuits end as scrap and need to be disposed of. The scrap is the root cause of a bullwhip effect that increments along the supply chain and that incurs in costs that could be avoided. Getting rid of the surplus parts leads to a huge waste of time, resources and money. Improve CKD kits usability or coming up with a better agreement with suppliers could help to reduce these problems.

Long lead times also cause major problems in the supply chain of the company. The time between order and delivery of the kits mostly lasts various months, which causes delays, quality issues and high costs to achieve the service level required. The length of lead times translates on the company choosing to purchase high volume quantity, which rises delays and quality risks impact but ensures lower costs on the order.
4.2 Interviews

The responses from the interviews performed during the internship were valuable. CKD production, recently adopted by the company (in 2007) is an essential part of the company's market share. It accounts for approximately 85% of the total annual revenue. The interviews highlighted some areas for improvement and some major issues found at each stage. Due to internal communication problems, geographical distance with the suppliers, the dynamic market in which the company operates, waste and cost caused by apparently insignificant errors rapidly skyrocket and constitute a big concern for the company. The content of the interviews has been summarised in the table provided in the Appendix.

It was recorded a general frustration towards reaching the set KPI of annual cost reduction. It has found to put a lot of pressure especially on the logistics and purchasing departments who have to continuously negotiate on lowering the prices. It also negatively affect quality. Because of the high volumes purchased, this continuous negotiation generally does not affect the relationship with the main supplier, however, it could come at the cost of open communication.
5 Analysis

This section answers the proposed research questions, based on the material presented in Section 4 and on the theoretical framework from Section 3.

5.1 Research Question 1

Understanding the context and the reasons for CKD adoption is essential. It was found that protection and rebuilding of local economies, the reintroduction of tariffs and quotas for domestic economies; introduction of taxes to fund local production and the reorientation of end goals of trade are drivers for CKD assembly (Colin, 2013). This is a pattern common to most of the cases CKD is applied in.

The analysis of theory and the contemplation on the observation result made it possible to come up with an answer to rq1: How can a company adapt its supply chain for CKD manufacturing? In order for companies to adapt CKD production strategy and carrying it out effectively and efficiently, they should consider the following.

Globalisation is a reality in which many companies, willing or unwilling, are immersed. Even though there is being a trend towards increasing service level and agility in the supply chain, thus decreasing distance between manufacturers and suppliers, reducing overall costs is still the main driver. The creation of GMNs, where each actor is specialised in one particular aspect of the supply chain and where the environment is characterised by open communication, transparency, cooperation and visibility should be the objective of any company working in a global supply chain. Such a change involves shaking the internal organisation of the firm in question. It is particularly challenging because it requires the collaboration and active participation of all the actors in the supply chain. This sets the need for excellent relationship with suppliers as well as management commitment. The design of the supply chain should consider TCE, keeping in mind lean concepts and value creation. As Golzer states, a company’s ability to respond to market changes is a success factor (Golzer, et al., 2014). This depends on close collaboration and integration with suppliers. By following the transaction cost economics framework, focusing on suppliers’ long-term relationship and monitoring their performance, problems can be addressed jointly, costs can be minimised and the adoption of CKD production can be justified (Grover & Malhotra, 2003). CKD supply chain can be very complex and does not fit every industry. Knowing the market sector, the socio-economic conditions of the supplier, the organisation location and governmental regulations is essential to take the decision on CKD. One of the main drivers to CKD assembly is to gain access to restricted market or to avoid high customs duties (Abele, et al., 2008). Additionally, many governments incentivise companies to produce by kit assembly. CKD allows gaining experience in a particular industry, while exporters of the CKD kits gains access to new markets (Freitas, et al., 2017), which results in a win-win situation for both parties. It can also motivate an increased pro-activeness in creating strong, exclusive relationships between buyers and suppliers, a key for supply chain efficiency (Bayo-Moriones, et al., 2011).

During the study the interconnectedness within various activities in the supply chain and the importance of communication and visibility at all stages became obvious. The organization generally sets a strategy and should ensure or require a certain level of visibility through its practices. Without clear and efficient internal communication, trying to have an efficient supply chain would be almost impossible. The level of internal visibility is reflected on the suppliers: with high requirements on open communication from both sides, many problems can be avoided. The insurance of a long-lasting relationship with suppliers, as praised by lean production process, is essential, especially to maintain service levels and high-quality standards. In practice is not that easy to achieve. Around all industries, reduction of logistics cost is a must. Focusing on the value stream is the best way to achieve an efficient supply chain, with minimum costs and waste.

Adopting CKD production require some changes in the organisation. It needs time to be adjusted according to the strategic plan and goals. It is difficult to come up with a standard guideline that can apply to every market, geopolitical contexts and industry fields, however, some general considerations for its efficient adoption can be outlined. The diagram below
provides with all the aspects a company need to consider before adopting CKD and is the result of the combination of the information collected during the case study and literature.

As highlighted by the diagram, the pros and cons of CKD in a particular industry sector should be analysed, together with the suppliers’ offers. Costs are of major importance in determining the next actions to be taken. Once deciding to adopt CKD, the situation needs to be further analysed for specific products. To adopt CKD, a company needs to have good internal integration and to ensure a great relationship with its suppliers. Also, it needs to check if CKD fits the market requirements. For example, if high service level is a must or if the products need high customisation, CKD might not be the indicated strategy. CKD is mainly characterised by long lead times, to combine cheap labour and material costs, with the benefits of assembly locally, close to the consumer market. If CKD is applicable and beneficial, then it should be adopted and can bring benefits to the company, if managed correctly.

Observations found that internal communication between departments, information integration and the use of internal software to collect and update production data are important for the successful implementation of CKD production. Bidding on lowest cost is not always the best option, because it can raise the total production price. Lead times, quality standards, flexibility and reliability of the supplier need to be considered. From design to delivery of the final product, the guideline is aimed at providing the main points to consider when thinking about implementing CKD production. Therefore a company can adapt CKD through the insurance of good integration and visibility and tackling the aspects highlighted in the framework provided. By taking each issue and assess it through Transaction Cost Economics analysis (Section 1) and applying the lean concepts provided in Section 3, the decision can be drawn.
5.2 Research Question 2

Literature Review, observations and interviews helped developing an exhaustive answer for RQ2, *What are the main causes of waste and cost within CKD manufacturing?*

Observations and interviews highlighted the main sources of waste at the company, while literature review helped to identify the most common sources of waste and cost. By using one of the frameworks provided in Section 3, waste sources can be prioritized according to their impact through FMEA analysis and eliminated through an appropriate strategy.

Research question 2 has been tackled following the framework for Waste Identification outlined in chapter 3 of this study. The first step is to define the value stream, below visualised by a diagram.

Raw materials are supplied to the first-tier suppliers by Asian factories. Those are then organised in kits. Quality inspection is carried out by the company at the factory, to avoid major errors in the delivered parts. If the inspection passes, the kits are shipped at the factory in Brazil, where, according to a FIFO strategy they are assembled for final product and distributed in the market. A lot of handling is involved and many steps do not actually change the product but involve transportation. Most of the transportation is unavoidable due to the great geographical distance between suppliers and buyers.

Ideally, all the non-value adding activities should be eliminated, but that is not always possible in real practice. A balanced supply chain requires trade-offs within the value stream, happening mainly around five dimensions: Procurement; Inbound Logistics; Operations; Marketing and Sales; and Outbound Logistics. Reaching the ideal situation for all of them is relatively impossible, therefore a company should focus on their area of expertise and reach the optimum level in that specific dimension. Balancing the costs, according to the context of the company, with the aim of finding the optimum solution with minimum costs and high flexibility and customer service levels is the objective. Resources and energies should be spent across various departments and inter-organisation to create stable, open relationships in compliance with GMNs principles.

After having identified the value stream, it is possible to outline the main causes of waste and cost. In this study they have been identified firstly according to waste types and then outlined. In CKD waste mainly comes in the form of: time; over-processing; transportation and underutilised talent. The first one is obvious due to the geographical distance and the long lead-time. Over-processing is a result of poor communication in terms of quality specification, lack of integration for order placement information and little transparency between the customer and the supplier. Transportation waste generates from the unnecessary costs arising from...
mistakes that cause delays, sometimes pushing companies to choose faster but more costly transportation modes not to lose responsiveness and service level. Underutilised talent results from the standardised assembly processes which do not allow much use of creativity or intervention from the employees.

The main causes of waste and cost found within CKD production are:

- Large inventories accumulation due to order quantity not being coherent with production or sales rate;
- Determination of the Order Quantity for kits by finding a common denominator among the exploded BOM of the product. For example, coming up with a Minimum Order Quantity of 10K is a decision weighted by many factors but does not mean that 10K products need 10K of each part. The accumulation of some unused parts and problems in managing them cause waste and higher costs;
- Long lead time causing discontinuity in production flow and queues; increasing internal costs;
- Quality problems that arise during the final assembly; could be caused by lack of training or handling;
- Delays in supplying the assembly line, reflecting in delays in final distribution;
- Possibility of order specifications mistakes, due to lack of communication and information integration between internal departments of the buying company and between buyers and suppliers;
- Quality problems and defects on one or some parts of the kit cause rejection of the entire product therefore delays;
- Forecasting problems resulting from the long lead times and sudden changes in the market;
- Incomplete kits, missing parts or defective that do not allow assembly and cause delays
- Continuous uncommunicated changes in the design of the product at different stages of the supply chain. It originates from a lack of integration.

Adapted from (Freitas, et al., 2017)

The information on the list has been further developed into a root cause analysis for the sake of a better understanding through visualisation. In the case company context, high delivery costs due to geographical distance can be solved by increasing the minimum order quantity. Rising that number gave rise to huge savings in the unit price of the components, which resulted in an overall reduction cost of 60%. This policy, however, has not solved the issue of defects or additional costs resulting from poor communication, poor quality or mistakes along the supply chain.

Once having detected root causes of higher costs and waste in production, the next step is “waste removal”. Waste removal can be carried out following a priority order, found using the equation for WPN provided in section 3 and the legend outlined in Table 3. The entire calculations are

Figure 11 Root Cause Analysis of Costs
Table 4 Root Causes Prioritisation

Knowing which cause to address first, appropriate corrective actions should be taken to eradicate them. Most of the waste during the visit to the company was found to be caused by mismanagement or lack of willingness to take responsibility for the mistakes found. Sometimes root cause analysis is not performed correctly or machines were not maintained due to the fear of stopping production and not meeting KPI goals of production. Handling of the parts, need to be careful and follow standards and specification.

5.3 Research Question 3

With the help of some already existing frameworks and thorough the results from the study, a general framework for the improvement of CKD supply chain could be drawn. It is based on the answer to both RQ1 and RQ2. It has been found that established routines ensured an efficient quality control process, which could be improved by working side by side with the supplier and eliminating errors from the source during the design phase. As described in the theoretical framework, early involvement of suppliers and effective communication integration are main factors. While the framework given in the answer to RQ1 was more about what to control to be able to effectively adopt CKD, the following framework seeks at finding a general guideline to apply for improving CKD supply chains.
The diagram is divided into the supply chain sections and has actions or suggestions for each one to take.

In terms of product development, it is highlighted the need to establish a good relationship and collaboration with suppliers since the beginning, starting at the conception and design phase. By clearly defining the objectives and goals for the products as well as the important features, and communicating that in a good way across the interested departments internally, problems should be avoided. Specifications in terms of materials, weight, features should be known and applied. To improve the supply chain for a CKD products, it is important to take into account from the conception phase that the products will be assembled and transported as kits. The use of materials that are durable, easily transportable and the break-down of the products into easily assembled parts needs to be communicated with the suppliers.

Regarding the purchasing phase, it is essential for a company to avoid bidding on low-cost since this has been proved to cause problems of quality and of lack of transparency from the supplier. Rather, the action to be taken is to identify that supplier that has the most optimum combination of quality and cost desired and develop a good relationship based on trust and clear communication. This will lead to long-term visible results and to a more stable supply chain of quality products, where problems can be recognised and solved in collaboration. Sometimes it can be applicable to lower prices by ordering higher volumes, which can result in significant discounts in transportation as well. However, this does not come without risks of damaging, late arrivals, of inventory accumulation and also, the cost of storing higher volumes needs to be calculated using TCE. What has been observed in the case study is that it often happens that similar products have same parts or similar parts. However, the suppliers might change the parts number, which causes problems if that number is not updated in the system.

Orders need to be digitalised across all departments, ideally using a database accessible to everyone and that automatically updates data. This would also increase visibility at all nodes. Additionally, when choosing a source, its geographical distance to the customer market also is to be considered. Depending on the type of products, it can be beneficial to work with suppliers that are closer to the market. This ensures easier communication and intervention in case of problems.

When dealing with any product that is sourced globally, but especially with CKD, long lead times need to be accounted for. Quality errors and delays should be minimised and worked with but are to be considered. Forecasting methods should be improved by triangulating different methods and combining results across big data analytics, historical data, routine tracking and market intelligence.

Quality, as stated early is an important aspect in the supply chain of products. Because CKD deals with global suppliers, specifications and requirements need to be clearly set. Linked to establishing a long term relationship with suppliers is also ensuring that those specifications are applied. Batch inspection is not an ideal practice, rather, the procedure needs to follow precise guidelines easy to check and to control. This helps identify and solve root-cause quality problems. This procedures need to be applied during assembly and the employees continuously trained. Management engagement and a drive to change is essential to be able to improve this stage.

To improve the supply chain of CKD products for companies that are new to the environment changes need to be made internally. For example, it has been showed in the case study that dividing the departments for products families is an effective way to quickly and efficiently solve problems, as teams. The culture should be one of openness to critics and suggestions, and employees should be critical in analysing and independent in their ways to tackle problems. Digitalisation of data and information through the same software is recommended.
Figure 12 Framework for CKD supply chain
6. Discussion and Conclusions

The chapter gives a summary description of the study’s results. Furthermore, the study’s implications and limitations are described. The chapter concludes with proposals for further research.

6.1 Discussion of Findings

The purpose of the study was to provide a framework for the improvement of the supply chain of Completely Knocked Down Products with a focus on waste reduction and cost efficiency. Such framework is provided in Section 5.

The findings reflect the information collected with the aim of improving supply chain for CKD products. The research questions build up to the achievement of the purpose of this thesis. Because of the lack of literature about the subject, finding, collecting and analysing data has not been easy. The difficulty in finding literature providing real data made observation at the case company essential. However, literature and definitions were essential to understand the industry context and be able to come up with recommendations. Overall, the reliability and validity of the study are ensured through the methods described in Section 2 of this study. The summary of the interviews and the information collected through observation is presented in the Appendix and in Section 4. The next subsection introduces small discussion points for each research topic that aided reaching the purpose of the investigation.

6.1.1 CKD Implementation

As shown, CKD does not fit all markets or industries. It is a strategy requiring well-thought planning and that is usually carried in a specific context where it brings benefit to the company. In fact, the strategy does not provide the final product with any additional value. The benefits lay in the organisational advantages. The main one being reduction of costs or tax and government incentives. CKD supply chain is complex and requires good supply chain management behind it. The topic of Global Manufacturing Networks and Glocalisation provide ideal situations in which CKD strategy would function at best. As stated information integration, visibility and communication among all the actors is important. The issue with that is how to avoid becoming overly dependent on each node of the chain, which is a phenomenon that can occur when the network is made of specialised actors sharing their core competencies. There can be flexibility problems since a minimum issue on one node could intensify along the supply chain fast and negatively affect all the parties involved. It was found that in case of over-dependency on suppliers, adopting a KD strategy with a higher level of local value added would strengthen a firm’s position in the industry (Erfurth & Bendul, 2018). Being immersed in a global environment also makes it more difficult for companies to stay close to their customer base and allow customisation. Complexity is too high. There is a need to invest in effective and efficient communication integration practices and technologies. At the bottom of the drivers for business it is the possibility to decrease logistics cost. TCE analysis promotes effective implementation of CKD, ensures focus on the valuable relationships, and helps to minimise costs and waste. Knowing where the transaction costs originate in a global environment can help coming up with a strategy to reduce them. Decreasing lead time through shorter supply chain is the most logical way to reduce uncertainty costs, caused by market fluctuations and the lack of flexibility. Another, more costly one is the increase in the frequency of orders, to allow OEM to promptly react to changes. In practice, these solutions are rarely effective or applicable. In reality, what should be done is to focus on internal measures and information integration. Once secured that internally, it would be easier to require that to external parties. Infrequency of demand can be solved through the levelling of the supply. It seems contradictory, but it highlights the importance of creating global networks. Once established the appropriate performance metrics and standards and having defined where the main problem lay, it is easier to come up with suitable solutions. The organisation should keep a mentality of continuous improvement and adapt to the market requirements. Having ensured excellence in communicating with suppliers and jointly address issues, quality is also insured. This should not come at high costs. Lowering total costs, not just unit raw material cost and maintaining a stable demand, despite market changes is considered ideal to keep relationships with suppliers optimal. Coming up with that “level schedule” can take years, but it is definitely well-spent
resources, which considers long-term benefits. Companies could protect themselves against the probability of delays by increasing the programmed lead time to cover potential delays.

The overall tendency supply chain management is to carry excess safety stock to compensate for the complex and abrupt changes in the demand. The cost that this excess inventory carries with it raises the overall logistics cost. JIT seeks to eliminate or at least reduce that cost. The continuous search for reduction of raw material costs by companies leads to buying in larger volumes, which results in greater inventory levels, exactly the opposite to the principle of JIT. Forecasting accuracy is essential: time series and linear regression give a good statistical baseline and big data analytics are of great help. However, organisations need to go beyond data collection and use day-to-day mining operations of real-time data to make better decisions (Nicoletti, 2018). The decisions should be driven by focusing on the total value delivered to the customer. As mentioned, complexity is high.

This study helped to understand that supply chains cannot be seen as “static blocks”. Rather, they are made by interconnected actors and stages, each one affecting one another. Quality cannot be ensured without good relationships with suppliers, which cannot exist without clear communication. CKD is a strategy that can provide companies with many benefits and result in considerable cost minimisation if managed correctly.

CKD manufacturing is a way to produce locally sourcing globally. It can help to reach sustainable globalisation, a market of global integration and consideration of local identity (Wiegerling, 2004). Companies need to develop more of a single partnership with suppliers, considering total cost based on overall carrying costs (Myerson, 2012).

6.1.2 Waste and Costs in CKD production

Ensuring quality is essential for high service level and supply chain performance, and it is also at the heart of lean philosophy. Establishing long term relationship with suppliers and measure output criteria such as quality, cost and delivery, for a smooth workflow and minimum inventory levels (Hines, et al., 2004) are essential lean concepts. Lean procurement is about long-term partnership with fewer suppliers and less reliance on low-cost bidding. (Myerson, 2012) It promotes keeping inventory levels stable with demand and maintain a stable production schedule (Ludwig, 2011). Meeting regularly with suppliers to manage capacity around material shortages and update forecast schedules help to ensure a stable material flow.

Many production planning systems do not plan for uncertainty and no effort is spent in the recognition of uncertainty sources (Kempf, et al., 2011). It was found that the main source of waste for CKD is scrap. Using Total Quality Management tools and investing in ensuring quality through communication integration rather than inspections, as well as through the application of some tools such as poka-yoke are elements that can help to reduce those problems. Reaching a “zero defects” production line is particularly challenging, but it is possible. What needs to be understood is that changes do not happen over time, and usually take a lot of time to be visible. With consistency, proactiveness to collaborate, continuous improvement policy and the involvement of everyone in the company, this process can be carried out. Consistency should also be part of the internal routines during final assembly, to make sure that the processes are continuously improved and in control. Some mistakes cannot be planned for such as sudden changes in the market, but frequent routine tracking and continuous assessment can minimise waste generated from errors and delays in the production. Quality issues should be solved jointly by suppliers and buyers.

The goal for an organisation finding quality issues should be to find the origin of the problem (supplier side or internal, and at which stage) and address it through appropriate actions according to which the strategy should be updated.

6.1.3 Framework for CKD Supply Chain

The framework resulting from the investigation provides with some general considerations to be made, which will improve the supply chain of CKD products. It is the summary of the information collected during the investigation. It includes the steps and actions that will help decreasing the accumulation of waste and cost in a CKD supply chain. It is a very general set
of actions, which if followed correctly, could help to set the basis for optimum management of the supply chain. It addresses the most important phases in the logistics phase. The main points are highlighted and actions are suggested. Companies willing to have an efficient supply chain of CKD products in a global environment should focus on working towards creating Global Manufacturing Networks. Identifying and assessing current and future needs, while coming up with the operational strategy and keeping in mind the elements of the framework will help them reaching improved performance. Because many of the problems encountered during the observations are mainly internal (quality problems during assembly and scrap for example), it is suggested to invest in digitalising the processes. Doing so would allow greater visibility and integration across departments and ease communication. It would also help identifying errors earlier on. To implement regular trainings and follow ups is also a beneficial practice to any company willing to reduce quality issues. The company culture should promote the development of a critical mindset and the possibility to solve minor problems independently. A good way to keep track of the production is to regularise processes and standardise guidelines so that they are both easy to follow and to keep controlled. Departments should work collaboratively towards total quality. Also, companies should consider purchasing based on TCE analysis, since it has been proven that low-cost driving purchases usually affect quality on the long-run. Backups and planning for uncertainty and long lead times is also beneficial to reduce waste.

6.2 Suggestions and Areas of Improvement

The delimitations described in section 1.4 highlight where the study lacks completeness and the areas where the study can be improved. The case study is focused on a particular industry sector in a particular country that follows some special procedures. This creates a need to further analyse supply chains from other industries and to go deeper into the problems, with more details. Also, during the observations, particular focus was applied to the process of purchasing and quality. Due to lack of time, not much information was collected about specific details of the design process. The lack of literature made collection of information challenging. Overall, the study is an attempt to give an overview of the entire supply chain of CKD process and some improvement actions that should be carried out. Observations and interviews were planned and carried in a way to keep the results as objective as possible, however, some subjectivity might have leaked. Collecting more of quantitative data about statistics on errors, waste, costs and corrective actions would have also benefitted the completeness of this study. Overall, the framework should be developed so as to provide more specific actions to take and measurable goals to improve supply chain performance. As it is now, it could be considered a bit vague.

6.3 Future Research

As highlighted throughout the entire paper, there is a need to further research into CKD production. Specifically, there needs to be more exhaustive collection of information on the application of such a strategy over different industry areas, complete of data and realistic results, to be able to come up with an improved framework. Future studies should also tackle specific stages of the supply chain in depth, to come up with specific actions for each part of the supply chain and further improve the CKD process. Figure 11 shows all the causes of waste and cost identified, future studies should tackle the different sources and find way to remove those causes or reduce them in order to further improve and control CKD supply chain. Additionally, specific frameworks for each supply chain section can be developed, in order to give industry complete and current information on how to efficiently organise the supply chain. Furthermore, more studies can be carried on in terms of implementing this strategy in different context, not only automotive and electronic industries and look at customization.
7 References


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## Appendix

Annex 1. Inspection Summary Checklist at the Company

### 1.2. INSPECTION SUMMARY

<table>
<thead>
<tr>
<th>SUMMARY</th>
<th>C</th>
<th>NC</th>
<th>R</th>
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</thead>
<tbody>
<tr>
<td>1. Process and procedure description</td>
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<tr>
<td>1.1. General revision changes</td>
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<tr>
<td>1.2. Inspection summary</td>
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<tr>
<td>2. General information</td>
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<tr>
<td>2.1. Packing standard</td>
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<tr>
<td>2.1.1 General</td>
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<td>2.1.2 Special parts packing</td>
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<td>2.2. Shipping labels</td>
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<tr>
<td>2.3. Defect standards</td>
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<td>2.4. Ad</td>
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<td>2.5. Invoice checking</td>
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<td>2.6. Bm - bill of material</td>
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<tr>
<td>3. Mechanical items</td>
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<tr>
<td>3.1. Assembly Test</td>
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<td>4. General design files</td>
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<tr>
<td>5. Electronic components</td>
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<tr>
<td>5.1. Boards</td>
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<td>5.2. Semi-finished Parts</td>
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<tr>
<td>5.2.1 Water Infiltration Test</td>
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<td>5.2.2 Waterproof Ring</td>
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<td>5.2.3 Thread Test</td>
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<td>5.2.5 Bracket Tests</td>
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<td>5.2.6 Connector Test</td>
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<td>5.2.7 Cable Test</td>
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<td>5.3. ICR + Lens inspection standard - VISUAL INSPECTION</td>
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<td>5.4. ICR + Lens inspection standard - FUNCTIONAL TESTS</td>
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<td>5. Responsibility and authority</td>
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Annex 2 Calculation process for WPN
Table 5 Risk Priority Number Calculation for CKD

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<th>Occurrence</th>
<th>Detection</th>
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<td>Quality problems found during ans after assembly (final)</td>
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<td>7</td>
<td>5</td>
<td>315</td>
</tr>
<tr>
<td>Quality problems at supplier side</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>315</td>
</tr>
<tr>
<td>Order quantity problems</td>
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<td>6</td>
<td>5</td>
<td>270</td>
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<td>Shipping Delays</td>
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<td>1</td>
<td>18</td>
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<tr>
<td>Sudden Market Changes</td>
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<td>2</td>
<td>1</td>
<td>18</td>
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<tr>
<td>Lead Times</td>
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<td>7</td>
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<tr>
<td>Scrap</td>
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<td>Reprocessing</td>
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<tr>
<td>Assembly Delays</td>
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<td>2</td>
<td>1</td>
<td>16</td>
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</table>

Table 6 Waste Priority Number Calculation for CKD

<table>
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<tr>
<th>Root cause</th>
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<th>Cost of Removal</th>
<th>Ease of Removal</th>
<th>WPN</th>
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<td>Quality problems at supplier side</td>
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<td>5</td>
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Table 7 Waste Priority Number Calculation for CKD

Annex 3 -Summary of Interviews’ content

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<thead>
<tr>
<th>Role</th>
<th>Main topics addressed</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Developer</td>
<td><strong>CKD importance</strong>; CKD is of main importance to the company. The majority of its products is assembled from kits. It represents the higher revenue source, but also the source of most of the costs and problems at the company. It is a particularly complex supply chain to manage, with many actors involved. Despite all the measures the company takes to protect itself against issues and quality problems, they seem never to stop rising. When a problem seem to be solved, another one pops out. For the company is essential to come up with new and durable solutions for the problem of scraps.</td>
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<tr>
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<td><strong>CKD marketing</strong>; the marketing for such products follows exactly the same procedure as any other product. We are still producing some items that in more developed (for example Europe or North-America) markets are outdated, such as chord telephones or some DVR options. However the Brazilian market still have a demand for it, therefore we continue producing it.</td>
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<td></td>
<td><strong>CKD development</strong>; development of new products involving CKD starts from checking with the suppliers’ offer. Usually we prefer not to start from scratch, since it would make the product more costly and require a lot of resources. The models from the suppliers however, need to be adapted to our market. Climate conditions are different. For example, for video-cameras, we have to consider humidity levels, rain, sun protection… Once we have the design, we need to test the product. The testing phase takes out a lot of time and is carried for stages: testing for vibration and drop-tests, as well as customer use tests. Every time problems are found we need to find the root cause and appropriate corrective actions. It depends on the product and on its criticality, but it takes on average 8-10 months to effectively launch a new product.</td>
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<td></td>
<td><strong>Purchasing</strong>; In the R&amp;D department we make sure that the product is well-functioning and then send the specifications to the purchasing team for initiating the negotiation. Some time they would come up to us and ask about changing one part</td>
<td></td>
</tr>
</tbody>
</table>
specification which would help reducing the price and, if possible, we act accordingly.

- **Quality Problems**: there are many problems rising from quality issues. The main ones being scrap. Sometimes there are batches that come in incomplete or present defects. Most of them just end in the bin, with no further action and the production gets delayed. Sometimes we have a part number and the purchasing team has another number, which also causes problems and delays. It is a system problem. Our system is still pretty old-fashioned. A lot of Excel sheets that not always get updated. We need to fix many problems. The main quality problems are luckily found in China, at the supplier side, but the time for corrective actions and implementation is long. When a quality problem is found at the final assembly, it is very costly to solve it; and requires even more time.

<table>
<thead>
<tr>
<th>Purchaser</th>
<th>1 hour</th>
</tr>
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</table>

- **Negotiation practices**: Negotiation is mainly carried out by email, very old-fashioned but it work for us. We also use Skype instant messages. Sometimes phone calls are necessary. For CKD we have a list of suppliers. We have one that we classify as critical, from which we supply most of the kits, and some smaller ones. Obviously, they do not know that we try to keep options open by scanning offers from several suppliers and then taking a decision based on total logistics cost. We usually already know which suppliers we should approach. Sometimes there are substantial variations in the prices and we need to look at other options, or try to lower the price based on the type of relationship with the supplier (if we buy frequently from them, we can ask for “loyalty” discounts) and on the shipped volume.

- **Supplier relationships**: since CKD is pretty complex, we have a few suppliers which we try to reach out for. Some we use more frequently, other for emergency. We try to keep good relationships with them, but sometimes there are trade-offs involved. We always look for the cheapest price and try to lower it in order to meet the KPI set by the management.

- **Internal KPIs of cost reduction**: sometimes it can get quite stressful to reach some price reduction. It is not always possible and coming up with a higher volume-ordering strategy is not a good solution. The total price of the product is calculated as the sum of all its parts, even though we purchase for kit. Therefore we need to work on Excel sheets and find out where the product can be lowered. These sheets are sometimes outdated and it can be confusing to know the current price.

- **Quality problems** we do not deal with quality issues, but we deal with reaching out with suppliers when such issue arise and are caused by them or originate at their plant. In these cases we need to ask them to cover the re-work or disposal costs, depending on the percentage of defect found. We follow a standard procedure for it.
- **Cost reduction.** Within the quality team, we are aware of the push towards cost reduction, but we also know that this sometimes comes at the expenses of quality. With the aim of purchasing cheaper raw materials, and saving money at that stage, more money is spent throughout the supply chain, especially in the inspection phase. It is resources, time and energy wasted in some problems that would not be present if there was a greater investment in quality.

- **Waste generation.** Waste is a big thing at the company. And it carries a lot of costs with it. Quality problems are rarely generated during transportation, and in the case that happens, insurance covers the costs. Waste generally originates from quality issues that were not detected during the stages at the supplier company.

- **Scrap accumulation** the worst stage where scrap can accumulate is at the end of the supply chain, where the product is already assembled. There we need to follow the procedure of identifying if the problem is a result of an error from an operator or if it was generated at the supplier side and not detected until the end. Both cases require corrective actions to be taken. We follow 8D procedures to deal with non-conformity and other quality issues. We have to identify the root cause, come up with good and effective solutions, establish corrective actions, follow-up and check if those actions are being incorporated into the strategy.

- **How to deal with delays and scrap** The main way we deal with scrap is through burning them by incinerator. It is a tedious process because we have to communicate this with the government and pay taxes on the scrap products. For this reason, we try to avoid them as much as we can and work with re-work instead. Sometimes however it is very difficult not to scrap. And it is expensive. For delays, we have safety stocks and rely on a “supermarket” in the production line, which is being replenished when necessary (as the items are being pulled). Delays are dealt with according to the criticality of the items, the more critical, the more expensive it will be to deal with them. If not critical, usually it means that it is possible to wait, otherwise, alternative transportation methods and more expensive, such as air freight are used.

- **Quality problems during assembly** this is getting a very hard topic. Our team of quality engineers needs to develop a more critical way of thinking. Most of the times when there is a problem encountered in the quality check during assembly or the final audit, the procedure is not followed correctly and the “guilt” is usually assigned to the supplier. However, it is not the case. The procedures should be followed, some items analysed and followed during the production process, with deep analysis about the condition between and after each stage. Only by doing this the real root cause can be found and appropriate corrective actions are taken. Additionally, even in the case, it is a supplier’s fault, it is important to try to think about available solutions to avoid to scrap the products. For example, we recently had problems with cameras showing a black spot in the image. Our
supplier applies a grey scale in order to decide to accept it or not because if the spot has graduation on the scale lower than 30%, the final customer will not actually be affected. We currently apply a binary system: if a black spot is there (identified with our powerful microscopes, the camera or the lens (depending on which stage the error is found) is scrap. This results in many cameras being thrown. We should be more flexible and start applying the grey scale to, since the thinking should be that if the defect does not affect the final customer, then is not a defect. Obviously, we are still aiming at full quality, but it is just about being more flexible and more practical with some things. It might be hard to convince everyone to adopt this strategy, but for the good of the company, it should be done. Also, sometimes in Manaus, we have problems about how the products are handled. For example, we encountered a lack of maintenance on some machines or harsh handling of fragile items or parts by the operators. This causes huge problems to the quality and most of the times they are not acted upon until I initiate corrective actions. However, I am not always in the factory, I mostly go 2-5 times per year. It can be hard to control quality from here. Part of the quality team is there on site, but as I said it can be hard to keep everything under control.

- **Design problems**, for design, we need to make sure that the products are adapted to our climate, which is generally more humid and hotter than in China. There are some specifications that we require, such as water resistance, for the outdoor cameras to be able to stand to the rainy season here in Brazil without being damaged. We sometimes find problems in the design of raw materials or kit parts. For example, cables being too fragile and having some problems or some problems arising from the design of the whole item. Those are fairly easy to fix since they fall under the supplier’s responsibility.

- **Importance of supplier relationship**, it is very important to be able to communicate with our supplier, share information and having a proactive relationship. Luckily, that is happening with our main supplier, who works with us, is now willing to share information on their manufacturers and take the corrective actions we require. It is not happening for the suppliers we ship less volume from. We cannot request too much from them since we really are of no worth as customers to them. When problems arise with those suppliers, it is a lot more difficult to tackle them.

- **Importance of CKD production**; for us CKD is very big. Not only is big, it is the biggest source of our profit but it is also the production presenting the most areas for improvement. We encounter many problems with these products, and representing high volume, for us is critical to solving them.

- **Main problems**, the problems are caused by the complexity of the operations. Dealing with China, producing in Manaus and having headquarters in Santa Catarina is difficult. We produce many different models of products. Main problems are the cost of
- **Logistics costs**, obviously the logistics cost for such items are big, due to the geographical distance. By shipping very high volume however, we can get discounts. Also, it is very convenient for us thanks to the tax benefits that we get from producing CKD, especially producing it in Manaus. The costs of shipping from China are totally balanced and for us, this is a convenient strategy.

- **Improvement and lean procedures at the company** we apply several lean concepts at the factory and headquarters. For example, in both, we follow 7s in the organisation of the factory and the offices. The factory provides the operators with clear visual messages and each item has its own market place. We also try to continuously improve both the processes and the strategy we are following. We set internal KPIs and make sure we have realistic but challenging production goals. As leaders in the Brazilian market, our company performs really well, but still, it cannot compete outside our country. We are still producing products (such are wired telephones that are way behind in terms of technology innovation for example).

- **Relationship with suppliers;** We try to keep a good relationship with suppliers. We currently have a team of Chinese engineers and salespeople from our main supplier to help us with the launch of a new product we are planning to launch by the end of September of this year. It can be difficult sometimes because we are pressured to keep prices low, but we are also concerned with having the best quality. Sometimes the trade-off is difficult to balance. We try to integrate information, but it already happened with some Chinese suppliers that we had quality problems because they were supplying their raw materials from sources that we did not certify and that did not meet the specifications. They were cheaper but not good quality. It can generate a lot of problems. Sometimes the main supplier it is not the best choice, so we try to have other suppliers around us, but the more they know us, and we know them, the safer the procedure.

- **Internal communication issues** Yes, we have an issue with our system. The communication could work better, we still mainly rely on emails which are not always effective and take a lot of time. We have a good, integrated internal system, that every employee can access at the company. However, updating the information sometimes requires more time than needed. Maybe we should invest in software for digitalisation of the processes and for making updating automatic and not manual. It would save a lot of costs and time lost in there.

- **Impact of delays in the delivery of products** it does happen sometimes that products are not delivered on time. That is because of problems at the supplier side and not be possible to address them at the right time. Sometimes those delays cost us a lot of money and for critical items, we have to urgently ship them.
by freight, which is insanely expensive. But the products comes fast.

<table>
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<tr>
<th>Logistics Analyst</th>
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<tr>
<td><strong>Forecast analysis</strong> we don’t really take care of forecasts analysis in our team. That is carried out in the sales department and the results are sent to us. We have to check their forecasts with the current inventory levels. The tricky thing is to align both and make the correct purchase order. Sometimes they ask us to order a lot of items, but we cannot do it because of current inventory levels.</td>
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<td><strong>Supply chain management</strong> everyone from our business unit has to participate to weekly meetings to determine the planning of the month or of the week, depending on the product or on the time of the months. Information and decision making is spread across the sector. The decision to place a final order is made by the management team, when they approve for the production plan established by R&amp;D, purchasing, Sales and after we check the inventory levels.</td>
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<tr>
<td><strong>Lead times</strong> our job is particularly complex because when we put an order, the waiting time is so big (around 120 days depending on the product) that sometimes during that time things have changed dramatically. Then we have to find solutions. And keep in mind that those solutions should consider quality and costs.</td>
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<tr>
<td><strong>Sudden changes in demand</strong> it gets particularly stressful when we have to deal with changes in the market demand. For example when the customers actually order less than forecasted or when we cannot supply enough materials. It doesn’t happen that often but it represents a great risk. It is very expensive when that happens to try to solve it. Sometimes we have to ship by air freight and negotiate with suppliers to give us a priority, sometimes we have to find ways to deal with the surplus.</td>
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Table 8 Summarised Interviews’ Answers