SUMMARY

During the economic development of the last decades, many companies have dedicated most of their efforts and resources in the generation of innovative products that allowed them to differentiate from the competition and gain market reach.

The implications in the cost structure of the development, production and distribution of these products have not traditionally been given the same level of analysis. However, it is a market reality that prices and costs play a very important role when it comes to achieving sustainable competitive advantage.

In this thesis, a general overview is initially given on the role played by the Supply Chain in large international enterprises, a more detailed look is given to the supplier-buyer relationships and the transfer pricing for the goods or services that are outsourced. As a next step, several methodologies are presented and discussed to assess the performance of the purchasing prices that are being paid. Finally, Linear Performance Pricing (LPP) is chosen as the suitable methodology to apply in two real life business cases in a large international enterprise of the construction industry. The applicability of the method is discussed for different groups of commodities, the methodology is described and the achieved results are outlined.

Finally, the potential results of the application of this method are outlined and their implications for the different departments of the company are described.

Keywords: Supply Chain Management, Sourcing, Transfer price, Pricing methodologies, Outsourcing, Supplier- Buyer relationship, Linear Performance Pricing, Regression Analysis
Durant el desenvolupament econòmic que s’ha produït en les darreres dècades, moltes empreses han dedicat una amplia majoria dels seus recursos al disseny i desenvolupament de productes innovadors que els permetessin diferenciar-se de la competència.

Els efectes que el desenvolupament, producció i distribució d’aquests productes poguéssin tenir en la estructura de costos de l’empresa han quedat en un segon pla i no han estat analitzats amb el mateix nivell de detall. No obstant, és una realitat dels mercats que tant els preus com els costos juguen un paper molt significatiu quan es tracta de generar avantatge competitiu a llarg termini.

En aquest projecte, es comença donant una visió global sobre el paper que juga la cadena de subministraments (Supply chain) en grans firmes internacionals. A continuació, es fa una descripció de les relacions entre l’empresa i els proveïdors, donant especial relevància al preu de compra d’aquells productes o serveis que són externalitzats. Com a següent pas, diferents metodologies per evaluar preus de compra són presentats i discutits. Finalment, Linear Performance Pricing (LPP) és elegit com el mètode adequat per evaluar la competència en el preu de compra per dos famílies de productes en una firma multinacional del sector de la construcció amb alt grau d’externalització. La seva aplicabilitat, metodologia i els resultats obtinguts son presentats.

Finalment, els resultats potencials que es podria esperar de l’aplicació integral d’aquesta metodologia en una empresa són presentats, juntament amb les seves implicacions per a cadascun dels departaments de l’empresa pels quals pot resultar beneficiós.

**Paraules clau:** Cadena de subministres, Compre, Preu de compra, metodologies per determinar el preu, externalització, relacions amb proveïdors, Linear Performance Pricing, Anàlisis per regressió
1 INDEX

SUMMARY ................................................................................................................................. 2
1 INDEX ................................................................................................................................. 4
2 TABLE OF FIGURES ............................................................................................................. 7
3 GLOSSARY ........................................................................................................................... 10
4 INTRODUCTION .................................................................................................................. 13
  4.1 Objective ......................................................................................................................... 13
  4.1 Methodology ................................................................................................................... 13
  4.2 Motivation ....................................................................................................................... 13
  4.2.1 The need to focus on costs .......................................................................................... 14
  4.2.2 Major Outsourcing trend ............................................................................................ 15
  4.3 Scope ............................................................................................................................... 16
  4.4 Limitations ..................................................................................................................... 17
5 BACKGROUND ..................................................................................................................... 18
  5.1 Hilti as a company .......................................................................................................... 18
  5.2 BU Installation systems ................................................................................................. 19
    5.2.1 Products of BU Installation ....................................................................................... 20
    5.2.2 Supply chain in BU Installation systems .................................................................... 23
6 INTRODUCTION TO THE SUPPLY CHAIN ..................................................................... 25
  6.1 Definition of the Supply Chain ....................................................................................... 25
  6.2 Understanding the Supply chain ..................................................................................... 26
  6.3 The role of Supply Chain ............................................................................................... 28
    6.3.1 Part of the value chain ............................................................................................... 28
    6.3.2 Source of competitive advantage .............................................................................. 29
7 THE ROLE OF SOURCING .................................................................................................. 32
  7.1 The make or buy decision ............................................................................................... 33
  7.2 Supply base structure ...................................................................................................... 34
  7.3 Supplier-buyer relationships ........................................................................................... 37
    7.3.1 Adversarial relationships ......................................................................................... 37
7.3.2 Collaborative relationships ........................................... 38
7.4 Fit on the organizational structure ...................................... 40

8 PRICING IN THE PURCHASING DEPARTMENT .............. 41

8.1 Definition of pricing ....................................................... 41
8.2 The challenge of achieving a good price performance .......... 41
8.3 Implications of pricing ................................................... 44
  8.3.1 Finance perspective ................................................. 45
  8.3.2 Marketing perspective .............................................. 48

9 PRICING METHODOLOGIES ........................................... 50

9.1 Linear Performance Pricing ........................................... 51
  9.1.1 The insufficiency of single regression ....................... 53
  9.1.2 Catalogue parts and drawing parts ......................... 55
  9.1.3 Application of Linear Performance Pricing ............... 56
    9.1.3.1 Definition of part families ............................... 57
    9.1.3.2 Identification of drivers ................................. 57
    9.1.3.3 Collection of data ......................................... 58
    9.1.3.4 Analysis of the data ...................................... 59
    9.1.3.5 Validation of the result ................................ 60
    9.1.3.6 Derivation of measures .................................. 62
  9.2 Other methodologies .................................................. 63
    9.2.1 Total Cost of Ownership ...................................... 63
    9.2.2 Cost Breakdowns ............................................... 65
    9.2.3 Comparison of methodologies ............................... 66

10 BUSINESS CASES ....................................................... 68

10.1 Components ............................................................ 68
  10.1.1 Identification of drivers ...................................... 69
  10.1.2 Analysis of the data and validation of the result ....... 72
  10.1.3 Derivation of measures ......................................... 77
10.2 Pipe Rings ............................................................. 81
  10.2.1 Identification of drivers ...................................... 82
  10.2.2 Analysis of the data and validation of the results ...... 84
  10.2.3 Derivation of measures ......................................... 88
10.2.3.1 Quotation check ................................................................. 91

11 CONCLUSIONS............................................................................... 92

12 BIBLIOGRAPHY............................................................................... 96
2 TABLE OF FIGURES

Figure 1: Extent of outsourcing in different American industries at the end of the 90s. (Gadde & Hakansson, 2001, p.5) ........................................................................................................... 16
Figure 2: Outsourced activities in American industries in 1996. (Quinn & Hilmmer, 1999, p.14) ........................................................................................................................................ 16
Figure 3: Overview of Hilti organizational structure ................................................................................................................................. 19
Figure 4: Overview of BU organizational structure ................................................................................................................................. 20
Figure 5: Example of Hilti Installation systems ........................................................................................................................................ 21
Figure 6: Example of Hilti Pipe Rings ....................................................................................................................................................... 21
Figure 7: Example of Hilti Installation components ................................................................................................................................. 22
Figure 8: Summary of Key figures of BU Installation Supply Base ............................................................................................................. 24
Figure 9: Diagram of the main stakeholders and flows to be considered in SCM (Larsen et al., 2007) ...................................................................................................................... 26
Figure 10: Framework of the Supply Chain .............................................................................................................................................. 27
Figure 11: The value chain (Porter, 1985) ................................................................................................................................................... 28
Figure 12: The Three Cs model and competitive advantage .................................................................................................................. 30
Figure 13: Drivers to gain competitive advantage .................................................................................................................................. 31
Figure 14: Main interactions of the Purchasing department with other departments of the firm .................................................................................................................................................. 33
Figure 15: Elements to keep in mind when designing the supply base .................................................................................................. 35
Figure 16: Communication between different department in collaborative relationships. ..... 39
Figure 17: Difference in aspects of collaborative and adversarial relationships. ............................................................................................. 39
Figure 18: Comparison between traditional highly vertically integrated value chains and modern less vertically integrated ones. .................................................................................................................. 43
Figure 19: Example of relative cost allocation throughout the supply chain of an outsourced good.................................................................................................................................................. 44
Figure 20: Visual Representation of financial KPI to calculate profit. .......................................................................................................... 46
Figure 21: Summary table of main financial KPI used in the chapter. ............................................................................................................. 46
Figure 22: Example for calculation of VGM and RoS .................................................................................................................................. 47
Figure 23: Comparison of the impact of purchasing price and sales on profitability. ............. 48
Figure 24: Impact on bottom line profit of sales increase and of cost reduction. ...................... 48
Figure 25: Variability of NSP with different types of customer. .................................................................................................................. 49
Figure 26; Example of scattered plot obtained in LPP analysis ........................................51
Figure 27; scattered plot of purchasing price in relation of weight of screws ......................52
Figure 28; scattered plot of purchasing price in relation to length of the screws .................53
Figure 29; scattered plot of purchasing price in relation to tensile strength of the raw material .................................................................................................................54
Figure 30; outline of how technical value can be calculated from single regression points ...55
Figure 31; Main steps to consider when applying LPP (Güthenke & Möller, 2011) ..............56
Figure 32; drawing and catalogue commodities and their possible drivers for an LPP analysis .........................................................................................................................58
Figure 33; scattered plot for same LPP model with different set of selected drivers...........59
Figure 34; Elimination of an outlier due to extremely high functionality in a LPP analysis ...61
Figure 35; division of two product sub-groups in two different LPP models .......................62
Figure 36; definition of benchmark line and detail of the different price levels that are obtained. .........................................................................................................................62
Figure 37; Example of the structure of a TCO calculation ..................................................64
Figure 38; Example of cost breakdowns calculation for a certain product group .................65
Figure 39; several examples of parts from the commodity components .........................69
Figure 40; two examples of how the variables are calculated in commodity components. ..71
Figure 41; initial LPP model for commodity components using all variables ....................71
Figure 42; LPP model for commodity components with differentiation between carbon steel and stainless. ........................................................................................................75
Figure 43; LPP model for commodity components only for carbon parts .........................75
Figure 44; LPP model for commodity components only for stainless parts .......................76
Figure 45; LPP model for commodity components carbon steel and with characteristic supplier ......................................................................................................................78
Figure 46; Identified potential savings per supplier for commodity components ...............79
Figure 47; Zoom into the area where most of the Supplier B parts lay ................................80
Figure 48; several examples of parts in the commodity pipe rings ....................................81
Figure 49; Pipe rings once they have been installed in a supplying system ......................82
Figure 50; Different types of closing mechanism for Hilti pipe rings ................................83
Figure 51; LPP model obtained for the carbon steel pipe rings .......................................84
Figure 52; LPP model obtained for the carbon steel pipe rings once the outliers have been removed and with characteristic set at product type. .................................86
Figure 53; Final LPP model obtained for the carbon steel pipe rings split by product family 87
Figure 54; Identified potential savings per supplier for commodity pipe rings. ..................89
Figure 55; Final LPP model obtained for the carbon steel pipe rings split by supplier. ...........90
# 3 GLOSSARY

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>3PL</td>
<td>Third Party Logistics</td>
</tr>
<tr>
<td>APV</td>
<td>Annual purchasing volume</td>
</tr>
<tr>
<td>ABC</td>
<td>Activity Based Costing</td>
</tr>
<tr>
<td>BU</td>
<td>Business Unit</td>
</tr>
<tr>
<td>COGS</td>
<td>Cost of Goods Sold</td>
</tr>
<tr>
<td>EDI</td>
<td>Electronic Data Interchange</td>
</tr>
<tr>
<td>IS</td>
<td>Installation Systems</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>LPP</td>
<td>Linear Performance Pricing</td>
</tr>
<tr>
<td>NSP</td>
<td>Net sales price</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>Rₘ</td>
<td>Tensile Strength</td>
</tr>
<tr>
<td>RFQ</td>
<td>Reference for Quotation</td>
</tr>
<tr>
<td>RoS</td>
<td>Return on Sales</td>
</tr>
<tr>
<td>R²</td>
<td>Coefficient of linear determination</td>
</tr>
<tr>
<td>Adj R²</td>
<td>Adjusted coefficient of determination</td>
</tr>
<tr>
<td>SAP</td>
<td>\textit{Systemanalyse und Programmentwicklung} (System Analysis and Program Development)</td>
</tr>
<tr>
<td>SC</td>
<td>Supply Chain</td>
</tr>
<tr>
<td>SCM</td>
<td>Supply Chain Management</td>
</tr>
<tr>
<td>T1</td>
<td>Tier 1</td>
</tr>
<tr>
<td>T2</td>
<td>Tier 2</td>
</tr>
<tr>
<td>TCO</td>
<td>Total cost of Ownership</td>
</tr>
<tr>
<td>VA</td>
<td>Value Add</td>
</tr>
<tr>
<td>VE</td>
<td>Value Engineered</td>
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<tr>
<td>VGM</td>
<td>Vertical Gross Margin</td>
</tr>
<tr>
<td>VMI</td>
<td>Vendor Managed Inventory</td>
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<tr>
<td>VP</td>
<td>Value Proposition</td>
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Preface

The present Master Thesis has been developed in the framework of the UNITECH International Program, more precisely during my internship with the company Hilti AG, which is a corporate partner of the programme.

I took part in 2009 in the Unitech program because it provided a perfect opportunity to combine my technical educational background, acquired throughout my Industrial Engineering degree in ETSEIB (Escola Tècnica Superior d’Enginyeria Industrial de Barcelona), with the development of more business related topics and the so-called soft skills (team leadership, presentation, coaching, etc.)

The Industrial Engineering degree has provided me with a solid technical background. However, it is my personal belief that in the current professional world it is not enough to bring outstanding technical capabilities. These capabilities need to be complemented with a good deal of management, team playing and communicative skills in order make use of their whole potential.

UNITECH is not only an exchange programme but also a community of technical universities and corporate partners that aims at filling in the gap missing between the academic world and the professional life. The core idea is to educate engineering students with soft skills and organizational competencies so that at the end of the programme they can act as a cornerstone between the technical and the business side of large international enterprises.

The program is consisting of three main components, the academic exchange, the internship and the three joint modules at the beginning, middle and end of the year. I did my exchange year in Chalmers Tekniska Högskola in Goteborg (Sweden), there I coursed the Supply Chain Management (SCM) master programme where I gained a lot of insights on the supply function in companies. I learned about the challenges that are found in the sourcing, the production and the logistics. Furthermore, I experienced a completely new way of learning with much more real life business cases and direct contact with companies. Getting to work with multicultural groups and living the Swedish way of working were also important learnings that I did during my stay in Sweden.
In order to complete my internship, I had the opportunity of coming to Hilti AG, in the Principality of Liechtenstein, where I could do an internship in the Supply department of the Business Unit Installation Systems. This implied a great chance to apply some of the concepts that I had learned during my studies, both as an engineering student in Barcelona and in the SCM master programme in Sweden. Hilti AG and its employees have provided a great atmosphere for the development of a successful Master Thesis. I have always been responsible for what I was doing and I have taken responsibility for the planning of my time and my resources. At the same time I always had the support of a great team of professionals that have supported with their dedication and very valuable input.

I have learned the importance of being cost sensitive and minimising the cost of the purchased goods and services in companies with high degree of externalization. Besides, I understood how this can be a source of competitive advantage and therefore a key success factor for companies wanting to succeed in a saturated market like the construction market is nowadays. I have seen different methodologies to assess the performance of the purchasing price and focused on the Linear Performance Pricing (LPP) as an analytical methodology to address pricing among different product families. I have applied the methodology myself to different groups of commodities and come up with suggestions for potential savings in future price negotiations.

The results of this Master Thesis are valuable since they are a good source of knowledge and data for the BU Installation. They help to understand where prices are too expensive or where an acceptable price level is agreed. These results can be applied not only on the Supply for future price negotiations but also have implications in other departments such as R&D and Marketing where having a good understanding of the main cost drivers can be of great help in future development projects.
4 INTRODUCTION

4.1 Objective

The objective of this thesis is to define a proper methodology that allows to assess the performance of the price paid for outsourced goods and services of large manufacturing companies.

This methodology could be used by the purchasing department of a large manufacturer (typically an OEM) with their tier 1 and tier 2 suppliers. Therefore, an expected outcome of the thesis is to have an analysis of the role that the supply chain, and more precisely the sourcing department plays in a company and to see how the application of such a methodology can contribute in creating sustainable competitive advantage towards competitors.

4.1 Methodology

In order to judge the different methodologies to appraise the pricing performance of the purchased goods, first, a theoretical overview on the role of the supply chain, and more specifically the purchasing function, will be carried out.

Once the role of the sourcing department is clearly defined, different methods will be presented, and their respective strengths and weaknesses will be outlined. Subsequently, one of the methodologies will be selected to attain an analysis of the performance price for the purchased parts of different commodities of purchased products in a large firm of the construction industry.

The focus will be given to LPP (Linear Performance Pricing) as an adequate methodology to perform such a price performance analysis. The needed steps will be presented and implemented and the applicability of the method will be discussed, highlighting the advantages and drawbacks that appear throughout the process. Finally, conclusions will be drawn on the applicability of the method and potential results and implications for different departments of the firms will be described.

4.2 Motivation

The necessity to evaluate the transfer price for the goods and services that enterprises decide to outsource is one that should not be underestimated. In general, no organisation, whether
governmental or business related, can stand alone (Skjott-Larsen, Scharý, Mikkola, & Kotzab, 2007, p. 17). Therefore, they face the need to exchange goods and services with other organizations. The transfer prices that are defined for these exchanges of goods or services often entail large percentages of the overall cost structure of the firm. As a consequence, having a good assessment on how expensive or cheap a company is purchasing their goods or services can have a big impact on the overall performance of the company. This becomes especially relevant in environments where there is a high cost pressure and in firms with a high degree of externalization.

4.2.1 The need to focus on costs

During the last decades many companies have put most of their efforts in the development of innovative products and services as a main source for achieving sustainable competitive advantage towards their competitors (Betz, 2011, p. 16-18), (Trent & Monczka, 2003). In this period markets have developed very fast. From the end of the World War II until today there has been a significant shift from a subsistence economy to a market economy. This shift has been especially noticeable in Europe and North America, but it has also affected big economies in Asia, South America or Oceania.

The possibility of free trade and the implantation of capitalism as the prevailing economic model have led to a higher degree of industrialization and specialization in many fields of the society. This has come along with an increase on the income and purchasing power for most governments, organizations, families and individuals. As a consequence of this increase in the rents, many companies have appeared seeking for business opportunities, trying to attract the largest possible portion of this new source of wealth.

The most common strategy to attract new consumers has been focused on developing more innovative products and services as a way to differentiate themselves from competitors (Betz, 2011, p.16-18), by doing so many companies have succeeded in remarkably improving their performance on the revenue side. The coexistence of large unexploited markets with a reduced number of competitors allowed companies to generate profit by focusing just on product development, marketing and sales while other functions of the company such as administration, operations and procurement have not been given the attention they deserve as significant cost generators.
Nowadays, companies face a challenging scenario, markets are more globalised than ever (Skjott-Larsen, Schary, Mikkola, & Kotzab, 2007, p.15), there is much more specialization and competition is much more tough both in number and in quality of the market players. Therefore, it is no longer possible for enterprises to solely rely on product differentiation in order to stay competitive (Chesbrough, 2003, p.35). Efforts need to be balanced in all sides of the business; having a good market reach is no longer a guarantee for business success unless efforts are also done for implementing best practices in the operational side, and having a good management of the Supply and logistics has proved to provide results on the overall firm performance (Swink, Golecha, & Richardsson, 2010). Most of the cost generators in a large enterprise can be allocated throughout the Supply Chain its products go through. Therefore, defining the right mechanisms to understand and minimise these costs has become a must for companies that want to stay competitive in today’s market (Cristopher, 2005, p.8-10), and one of the main cost drivers is the cost of the purchased goods and services, especially for enterprises with a large degree of externalization.

4.2.2 Major Outsourcing trend

Throughout their whole value chain, companies face the challenge of performing and coordinating a wide range of activities. The number of activities that need to be performed by an enterprise in its regular business can depend on different factors. The type of product, the accessibility of the market or the utilised raw material can define many different sets of activities that are needed to bring a certain product to the market. Taking into account the premise that no organization can be good at all things, companies face the need of defining their core competences upon which they want to sustain their competitive advantage. (Porter, 1985, p.20-23). Activities that are not considered to be a core competence of the company, are not of primary importance for the strategy of the firm and therefore are likely to be outsourced to other companies.

There is evidence that the percentage of outsourced activities in major companies has increased in the last decades (Gadde & Hakansson, 2001, p. 39-42). The reasons for this increase are mainly the higher degree of industrialization, that leads to more sophisticated products, and the globalised economy.

As a result, companies purchase a higher percentage of the goods and activities that are embedded in their value chain (Mattsson, 2000, p.95-100) and consequently the prices they
pay for this outsourced activities have a bigger impact on their cost structure and ultimately on their overall financial performance (Kraljic, 1985, p.109-110).

<table>
<thead>
<tr>
<th>High extent of outsourcing</th>
<th>%</th>
<th>Low extent of outsourcing</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textiles</td>
<td>62</td>
<td>Utilities, gas and electric</td>
<td>17</td>
</tr>
<tr>
<td>Motor vehicles and parts</td>
<td>61</td>
<td>Petroleum refining</td>
<td>21</td>
</tr>
<tr>
<td>Chemicals</td>
<td>57</td>
<td>Food manufacturing</td>
<td>38</td>
</tr>
</tbody>
</table>

Figure 1: Extent of outsourcing in different American industries at the end of the 90s. (Gadde & Hakansson, 2001, p.5)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Finance and accounting</td>
<td>18%</td>
</tr>
<tr>
<td>General administration</td>
<td>78%</td>
</tr>
<tr>
<td>Human resources</td>
<td>77%</td>
</tr>
<tr>
<td>Information systems</td>
<td>63%</td>
</tr>
<tr>
<td>Marketing</td>
<td>51%</td>
</tr>
<tr>
<td>Transportation and distribution</td>
<td>66%</td>
</tr>
</tbody>
</table>

Figure 2: Outsourced activities in American industries in 1996. (Quinn & Hilmer, 1999, p.14)

Figure 1 shows the percentage of outsourced activities in different industries in the United States and Figure 2 shows which are the services that are more commonly outsourced.

4.3 Scope

This thesis elaborates on the importance of the purchasing price in the sourcing department. The main target is to validate a method that allows reducing purchasing price of goods purchased.

The analysis and expected outcomes aim at having a global perspective. However, while the theoretical framework is a valid conceptualization of the role of the supply chain and the sourcing department for any business or industry, the conclusions that stem out of the practical business cases are particularly relevant to the purchasing environment where they have been performed. This environment is described with more detail in chapter 5 Background, and basically consists of the sourcing department of a large manufacturer of equipment for the construction business.

In this thesis, one of the methodologies that are presented and used is Linear Performance Pricing (LPP), this methodology involves the use of statistical methods and complex mathematical algorithms. It is not the target, neither the focus, of this thesis to analyse in detail the
mathematical background of the method. Instead, the applicability of the methodology is discussed and the conclusions that can be derived presented. While the main statistical parameters to be checked are presented, the calculation of these parameters is done with the statistical software Analycess Procurement Lite. The details on the mathematical algorithm behind are considered to be more appropriate for a purely mathematic or statistic thesis and are, therefore, not analysed in this paper.

4.4 Limitations

Given the fact that this thesis is realized in cooperation with a private company (Hilti AG), some information and data cannot be published. The information regarding prices and purchasing volumes cannot be shared because its disclosure could incur in a severe business risk for the company. Hence, whenever a confidential figure needs to be given, such confidential data will be multiplied by a factor of X so that it still keeps a linear correlation with reality but does not disclose any confidential information.

Another limitation of this study arises from the time frame in which it is realised. Implementing such a methodology is feasible in a 6 months internship, but drawing down conclusions about the impact that this can have in the long term can be a bit premature in such a short period of time. The added value of having a good pricing methodology can be evaluated, and its applicability can be judged on immediate price negotiations with suppliers, but the effects that such a methodology can have on the long term can only be predicted, but not contrasted with real facts.
5 BACKGROUND

As previously mentioned, this thesis is realized in cooperation with the company Hilti AG, during a 7 months internship in the purchasing department of the BU Installation Systems.

5.1 Hilti as a company

Hilti Corporation (Hilti Aktiengesellschaft or Hilti AG) develops, manufactures, and markets products for the construction and building maintenance industries, primarily to the professional end user. It is well-known for its direct fastening activated tools, hammer drills, sawing machines, anchors, fire stop and installation systems.

Hilti was founded in 1941 by Martin Hilti with the opening of a small mechanical workshop in Schaan, Principality of Liechtenstein. Since then, the company has grown and has built up a complex sales network worldwide, which is nowadays probably one of the most relevant characteristics of the Hilti Business Model, the direct sales force that enables up to 200,000 direct customers interaction every day. All Hilti products are sold via the Territorial salesman (TS) or the Hilti Center.

Nowadays, Hilti employs more than 20,000 people in 120 countries and generates annual sales of roughly CHF 4 Billion. In the headquarters in Schaan, the company employs around 2,000 employees. Hilti is structured according to its corporate strategy where all processes are intended to add value for the customer, for whom the company tries to generate innovative and outlasting solutions.

The different BUs that have been appearing since its foundation to give response to the different needs that can be found in the construction industry account for the majority of employment in headquarters. These BUs are currently embedded in two big Business areas (BA); Electric Tools and Accessories (comprising BU Power Tools and accessories, BU Diamond and BU Measuring Systems) and Fastening & Protection Systems (comprising BU Anchors, BU Installation Systems, BU Direct Fastening, BU Chemicals). Some corporate functions, such as the Corporate Research and Technology (CR&T) and the Supply Chain can also be found in Schaan. Top Management and owners (Martin Hilti foundation) also remains in Schaan.

The sales force is delegated to the regions, also known as Market Organizations (MO), which have the main function of sales and market reach and development as well as collecting and providing feedback about customer experience with Hilti products so that better solutions can
be designed. The MOs spread around the whole globe enabling the direct sale of Hilti products in 120 countries worldwide.

Figure 3: Overview of Hilti organizational structure

5.2 BU Installation systems

BU Installation Systems was founded in 1991 as a part of the consumables business of Hilti. Ever since then has developed innovative solutions to support construction professionals specialized in providing solutions in the installation of supplies to housing (water, gas, heating, etc.) and commercial buildings with lines for fresh water, waste-water, warm water, heating, fresh air, gas and electricity and disposal of exhausted air and sewage in housing, commercial building. BU Installation Systems also encompasses applications developed to install complex heavy duty energy supply and piping applications in industrial and civil complexes like factories, oil platforms, refineries, power plants, tunnels, etc.

Nowadays BU Installation Systems is integrated in BA Fastening and Protection systems and is structured in the same way as the rest of BU's in the Hilti Group. These means three main business functions are coordinated within the BU; marketing, development and supply (which includes sourcing and materials management) and with direct reporting to the BU management while other support functions such as quality, controlling and human resources belong to
separate unit but work within the BU and report through dotted line to the BU management team.

![Diagram of BU organizational structure]

**Figure 4: Overview of BU organizational structure**

### 5.2.1 Products of BU Installation

BU Installation Systems provides solutions for professionals in the installation of supplies to housing, commercial building and also industrial applications. The main specializations that are covered are:

- Installation of water, air, heating, gas and electric supplies.
- Design and implementation of heavy duty energy supply and piping applications in civil and industrial facilities.

The vast majority of the products is designed and developed by Hilti to be part of an installation system solution, therefore they are Hilti specific products that refer to a particular drawing and specifications. The products from BU installation can be clustered in three main commodities groups; installation channels, pipe rings and components.

- **Installation channels**

  This group includes the channels and girders that build up the structure of the system. They are designed to support the needed loads and to be able to fit the highest possible number of connectors so that the final solution can adapt to almost all kinds of geometry without any need for welding. These channels are produced in several kinds of carbon steel and stainless steel and offered with different surface treatments (galvanized, HDG, HDG+) and they are produced using roll forming manufacturing technology.
Pipe Rings

The pipe ring is the key element that allows the installation of pipes. Their function is to hold the pipe and therefore the needed mechanical loads and requisitions need to be fulfilled. Furthermore, they also need to provide good thermic isolation so that the extreme temperatures of the fluids that go through the pipe are not transmitted to the installation support or to the environment. This isolation is in most cases achieved with EPDM rubber although other kinds of foams and plastics are also used.

Another important feature in pipe rings is the clamping mechanism that they use. Given the fact that this pipe rings need to be installed in high places it is often complicated to proceed to close them and therefore a clever solution is needed to increase productivity and security in the installation of pipes. In this regard different solutions are offered, one screw, double screw or the Hilti own system known as *crocodile*. 

Figure 5: Example of Hilti Installation systems

Figure 6: Example of Hilti Pipe Rings
Components

Components are the elements that enable the connection of the different channels and pipe rings between each other. They connect, fasten and fix the different elements that make up the installation solution. They are designed with the aim of maximising the total number of geometries that will be able to be achieved. In general, they are mechanized parts that are manufactured with different technologies; bending, stamping, punching, welding, etc. but they can also be assemblies of several components (nuts, screws, springs, etc.).

There are two main groups of components. The standard components cover all the needed screws, washers, nuts and threaded rods that can be found under the European DIN standard or the American AISI. On the other hand we find all the engineered components that are designed and developed by Hilti, this are drawing specific items.

These components are manufactured in carbon and stainless steel and with a variety of surface treatments (galvanized, HDG, HDG+).

![Figure 7: Example of Hilti Installation components](image)
5.2.2 Supply chain in BU Installation systems

As stated in previous chapters, Supply is one of the functions that remain within the core of the BU management in the Hilti business model. This is also the case for BU Installation systems, where the supply function is executed in close cooperation with marketing and product development and plays an important role in the Business Unit road map.

The SC in BU Installation is divided in two main functions. On the one hand, Materials management takes care of the actual logistics and goods flow between the Suppliers and Plants and the different markets distribution centres. On the other hand the Supply management which takes care of the procurement. This involves selecting the right suppliers for each product, auditing them, manage the lead buyer function and defining the right logistics set up from each supplier to the different markets. One of the most important characteristics of BU Installation supply chain is the fact that 99 % of the products are completely outsourced to external suppliers.

Having such a high level of outsourcing involves a great deal of responsibility and a huge capacity for the procurement to affect the overall performance of the BU. The selection of the right suppliers is closely related with the quality of the products that will ultimately arrive to the customers and therefore having a good sourcing is a prerequisite for achieving customer satisfaction. Furthermore, the big degree of externalization implicates a huge impact of the purchasing price for the goods outsourced in the financial performance of the business. The cost of goods sold (COGS) basically relies on the prices that are agreed with the suppliers and it becomes a crucial Key Performance Indicator (KPI) to monitor in order to achieve bottom line profitability.

Although most of the supply base is located in Europe, there are also suppliers in Asia and North America. The consolidation of a supply base in those markets where sales are starting to ramp up and consolidate supports the overall supply strategy for Hilti, that wants to supply in a “local to local” approach in the near future. This local supply bases are controlled by regional satellite offices but still steered and coordinated from headquarters in Schaan where Hilti wants to keep its main “centre of excellence”.

<table>
<thead>
<tr>
<th>Number of parts outsourced</th>
<th>~ 3500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of direct suppliers</td>
<td>~ 60</td>
</tr>
<tr>
<td>Number of direct A suppliers</td>
<td>~ 15</td>
</tr>
</tbody>
</table>
The main raw material for Installation systems products is steel (mainly carbon steel but also stainless). Other relevant raw materials are zinc (for the galvanization treatments) and rubber (for some components). Most of the suppliers are industrial medium sized companies that mechanize the parts according to Hilti drawings and specifications using a wide variety of manufacturing technologies (roll forming, stamping, welding, grinding, etc.). In many cases Hilti also interacts with tier-one and tier-two suppliers in order to ensure the quality of the purchased goods as well as to drive COGS reduction strategies.
6 INTRODUCTION TO THE SUPPLY CHAIN

The Supply Chain (SC) is one of the functions that can be found in any organization that aims at providing goods to a certain market. These organizations face the challenge of sourcing, producing and distributing goods between different locations, from sourcing points to end customers. The underlying reality is rather simple. Whenever a good is delivered to a customer, it leaves behind a series of actions that have enabled the final execution of this transaction (Skjott-Larsen, Schary, Mikkola, & Kotzab, 2007, p. 17).

From the purchase of the raw materials that are needed for the manufacture, the consolidation and transformation of these raw materials through a production and assembly process and the later distribution of the goods throughout the warehouses and different selling points, there is a complex network to handle.

The objective of the Supply Chain is to make sure that this sequence of actions is carried out as efficiently as possible, providing responsiveness to market requirements while maintaining the lowest possible cost level.

6.1 Definition of the Supply Chain

There is little consensus in the current literature about what can be an accurate definition of the Supply Chain. Martin Christopher (Christopher, 2005) defines the supply chain as concept of closely coordinated, cooperative networks competing with other networks. Another definition claims the SC to encompass all the organizations and activities associated with the flow and transformation of goods from raw material through to the end user (Handfield & Nichols, 2002). The SC is also described as a set of three or more companies directly linked by one or more of the upstream or downstream flows of products, services, information or finances from source to end customer (Mentzer, 2001, p.15-17).

The definition that is considered suitable for the interpretation and use of the SC term done in this thesis is the one given by Skott-Larseen (Skjott-Larsen, Schary, Mikkola, & Kotzab, 2007), defining the SC as a linear sequence of operations organized around the flow of materials from source of supply to their final distribution as finished goods to their potential end users.

It is also important to differentiate the concepts of Supply Chain (SC) and Supply Chain Management (SCM). The term SCM is relatively new and has appeared in the last decades with the globalization of the markets and the specialization of companies that has ultimately
led to a less vertically integrated value chain (Güthenke & Möller, 2011, p. 3). SCM is a wider concept than SC, it emphasizes on the integration of the needed business processes and the coordination of these processes within the different functional lines that can be found within an enterprise. Such processes can be certainly allocated within the Supply Chain department but also affect other adjacent business areas inside (marketing, sales, IT) and outside (suppliers, 3PLs, customers) the firm.

In this thesis the focus is on SCM rather than only SC and the following definition is considered to be the most accurate one. SCM encompasses all planning and management of all the activities involved in sourcing and procurement, conversion and logistics. It also includes coordination and collaboration with channel partners such as supplier, 3PLs and customers. (Skjott-Larsen, Schary, Mikkola, & Kotzab, 2007, p.21) (Mentzer et al., 2001).

![Diagram of the main stakeholders and flows to be considered in SCM (Larsen et al., 2007)](image)

### 6.2 Understanding the Supply chain

Understanding the global SC is a prerequisite to managing it, in order to do so a static view of the SC will be initially considered. When freezing the SC at a particular point in time three major components can be identified; activities, organizations and processes.

These three components are enveloped within an internal SCM that is leaded from a more global and strategic perspective. Activities are the foundation, the building blocks of the system and can only be justified within the Supply Chain if they add value to the overall flow
process. They can be reorganized by sequence and eventually eliminated if not needed anymore, they can also be shifted within organization to improve performance (outsourcing). Organizational units are responsible for actually executing these activities, they can be both internal or external to the firm and according to the resource based view of the firm become the repositories of the resources that are used for the execution of this activities (Eisenhardt & Martin, 2000) and ultimately hold responsibility for the execution of activities.

Processes are larger sets of coordinated activities that are aligned to achieve a final result. For example, Order processing is an activity that is part of the purchasing process. The particular activity of placing an order happens between two organizations (typically the firm and a supplier) and therefore crosses organizational boundaries, thus requiring previously agreed processes.

![Figure 10: Framework of the Supply Chain](image)

These three major components are embedded and affected by the corporate management of the firm that will determine the strategic objectives and depending on the company culture also the way processes and activities are defined and executed.

In this paper, the purchasing function will be seen as one of the processes that needs to be carried out in Hilti, pricing (more precisely price negotiation) is understood as one of the activities that needs to be done in the process of purchasing that occurs between two organizations (Hilti purchasing department and a supplier).
6.3 The role of Supply Chain

The role that the SC plays in the firm is analysed and described from two different perspectives; as part of the value chain and as a source of competitive advantage towards the competition.

6.3.1 Part of the value chain

The underlying framework to understand what is the role of SC in the firm is the value chain concept developed by Michael Porter (Porter, 1985).

In this model a series of primary activities are described, the common ground to all these activities is that they add value to the final output of the firm. These primary activities are inbound logistics, operations, outbound logistics, marketing and sales and services. Together with these primary activities a set of support activities is defined; human resources, technology development and procurement. Within this model the activities performed by the SC can be identified both as Primary and Support activities. It is not crucial to differentiate whether the SC is a primary or a support activity but to assess whether the output of the activities performed by the SC really bring added value to the firm’s final product. Having the products in the right place, at the right moment and in the right conditions is certainly something that customers in the construction industry are willing to pay for and therefore the SC (logistics and procurement) are undoubtedly part of the Hilti Value Chain. Another debate can be opened about what is added value and what is not, for this paper we will be aligned with the overall Hilti strategy, and thus consider that added value is everything that customer is willing to pay for. The following box illustrates a checklist were value analy-
sis (VA) can be easily carried out on an item basis, although most of the points can also be adapted to the processes and functions that are performed within the value chain of the company. Besides this VA analysis it is also important to consider those elements that bring knowledge to the company and that will also ultimately bring added value, although in this earlier stages of the development of a product are usually referred as value engineering (VE).

<table>
<thead>
<tr>
<th>Elements of value analysis</th>
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</thead>
<tbody>
<tr>
<td>1. Can an item be eliminated?</td>
</tr>
<tr>
<td>2. If an item is not a standard, can a standard be used?</td>
</tr>
<tr>
<td>3. If it is a standard item, does it really fit the application or is there any misfit?</td>
</tr>
<tr>
<td>4. Does the item have greater capacity than required?</td>
</tr>
<tr>
<td>5. Can the weight be reduced?</td>
</tr>
<tr>
<td>6. Is there a similar item in inventory that could be substituted?</td>
</tr>
<tr>
<td>7. Are tolerances over-specified for the real needs?</td>
</tr>
<tr>
<td>8. Is unnecessary machining performed on the item?</td>
</tr>
<tr>
<td>9. Are unnecessarily fine finishes specified?</td>
</tr>
<tr>
<td>10. Is commercial quality specified?</td>
</tr>
<tr>
<td>11. Can the item be manufactured cheaper in-house or outsourced?</td>
</tr>
<tr>
<td>12. Is the item properly classified for shipping in order to obtain cheaper transportation costs?</td>
</tr>
<tr>
<td>13. Is the packaging optimal?</td>
</tr>
<tr>
<td>14. Are suppliers taken into consideration for potential cost reduction measures?</td>
</tr>
</tbody>
</table>

Source: (Webster, 1991, p.54-55)

6.3.2 Source of competitive advantage

The other function that the SC plays in the firm is as a source of competitive advantage towards the competition. In other words, the function performed by SC enables and endures superiority over the competitors in terms of customer preferences by affecting crucial aspects of the product offering. (Christopher, 2005, p.6-7). There might be several foundations for final success in the market place but one of the most generally used model is the “Three Cs”, this model reflects the triangular linkage between customers, company and its competitors.
In Figure 12: The Three Cs model and competitive advantage we can appreciate what are the main relations between the three pillars of the model. On the one hand, the company and its competitors will be seen from the customer perspective as a product or service provider. More precisely, they will be seen from the customer perspective as the provider of a solution that adds value to their specific needs. Therefore, the first mechanism to generate this competitive advantage will rely on the ability of the organization to differentiate itself (in a positive way) from the value proposition offered by its competitors. (Porter, 1985, p.115-120),(Christopher, 2005).

This type of competitive advantage is known as value advantage and can originate from the product itself but can also be achieved through the SC (Mattsson, 2000, p. 135-140). Although the SC has traditionally been related to the physical distribution of goods, the modern SC also can affect the final value proposition that customer will perceive, by selecting the right materials, delivering in the right place and time and supporting many of the after sales customer services.

Another way that the firm can differentiate itself from the competition is by reducing the costs of the products or services that are offered, this can result in a reduced final price to customer. In this case is cost advantage.

It is generally accepted that in a given industry the capacity to achieve lower costs will depend on the volume that each of the players is handling. This is something which has proven to be true since the Second World War for many industries.
There are two main reasons for this reduction in costs; the first of them is economies of scale, which enable fixed costs to be spread over a greater volume with the ultimate effect of reducing the cost per each individual item. The second of them is related to the experience curve (Christopher, 2005, p 7-8). This curve shows that it is possible to identify improvements in the rate of output of workers as they become more skilled in the processes and tasks they need to perform, evidently, the higher the number of times a worker needs to perform an action the more skilled he will become on it.

Even though the linkage between market volume and relative costs is out of doubt, it must also be recognized that supply chain management can provide many ways to increase efficiency and productivity and hence contribute to reduced unit costs (Christopher, 2005). Actually, proving that this is possible by defining the right methodology to assess price performance of the purchased goods is the main goal of this thesis.

As a summary to this chapter, SCM can significantly affect the two drivers for competitive advantage, and it is actually one of the few functions in the company that can affect both of them. The organizations that lead the markets have sought and achieved good levels of excellence in both dimensions and in many cases the way to achieve it has been focusing on SCM (Johnson & Simon, 2011).

Figure 13: Drivers to gain competitive advantage
7 THE ROLE OF SOURCING

Business organizations do not typically own all of the resources or provide all the needed activities necessary to produce a product or service (Gallager, 1999, p.164-168). The reason for that is not only that trying to englobe the whole set of activities would be prohibitively expensive but also offers the possibility to other organizations to focus on a particular step of the process thus delivering higher expertise and performance.

Buying goods or services from outside sources instead of producing them within the organization is defined as outsourcing (Mattsson, 2000, p.225-226). For example, many industrial companies will purchase components that they have designed for their products to outside suppliers. These purchased parts will be consolidated within the firm manufacturing facilities for assembly with other purchased or self-manufactured parts. Services are also commonly outsourced, typically outsourced services are transportation, data processing or facilities maintenance (gardening, cleaning).

One of the main responsibility of the sourcing function (also known as procurement or purchasing) is to ensure the availability and quality of those services and goods that the firm has decided to outsource. It is also important to ensure that this services are achieved in adequate prices and to be able to establish trust-based and long term relationships with key suppliers and strategic stake holders (Mentzer, DeWitt, & et al., 2001).

Purchasing acts in many cases as the corner stone of many other activities of the company, therefore continuous interaction with most of the departments is needed and the information flows that originate among them need to be handled properly. As an example, purchasing has a direct impact on the quality of the purchased goods, therefore interaction with quality is often required. Also with Controlling the interaction is often necessary since the development of the purchasing prices of the goods might have severe consequences on the profitability of the business. In Figure 14 the relation of purchasing to the other departments is shown and the main information flows among them is noted.
In order to achieve so Gadde & Hakkanson (Gadde & Hakansson, 2001) establish three main areas of decision for the procurement;

- Make-or-buy decisions
- Supply base structure
- Supplier relationships

**7.1 The make or buy decision**

Although the decision whether to produce in-house or outsource has been a rather fundamental issue ever since the industrial revolution, it was not given the strategic importance it deserves until the 1990s (Gadde & Hakansson, 2001). Corporate Management has during many years given this decision to their purchasing managers that in many cases have decided based on short term, retrospective cost data and estimations on future capacity utilization (Jauch & Wilson, 1979). The need of involving procurement in the make-or-buy decision is out of doubt due to the best knowledge and proximity to the marketplace that purchasing managers hold, but since this decision determines to a very large extent the boundaries of the firm there is a clear need to align this decision with the corporate management.

Prior to deciding whether a good or service needs to be outsourced, the management needs to define what is the core competence of the firm. This core competence will be the process, activity or knowledge where the firm has already developed advanced skills that can use to sustain competitive advantage of its product offering. (Mattsson, 2000, p.222-225). A
company should never outsource its core competence because this could lead to a significant loss of its position in the value chain with the ultimate risk of being completely overtaken by the supplier and losing its market position. Defining what are the core competencies might not be an easy task, Gillett (Gillett, 1994) proposed the following characteristics to identify activities that are part of the strategic core of the company:

- Provide management and direction
- Maintain competence and control
- Differentiate the company from its competitors
- Establish uniqueness

Once the core competences has been identified, those activities which are not part of it can be considered for outsourcing. According to Quinn & Hilmmer (Quinn & Hilmmer, 1999, p.9-21) focusing on the core competences can provide three main strategic advantages:

- The company might maximise the return on internal resources by concentrating efforts on areas where it has already developed and advanced capability.
- The development of the core competence will function as an entry barrier for competitors.
- Benefiting from the specialization and flexibility of a third party that is completely focused on a particular process which is, indeed, its core competence.

According to Morgan (Morgan, 2000, p.5) the following list of questions should be considered when evaluating the convenience of making or buying each of the activities in the value chain of a company.

- Is there a competitive advantage to keep this in-house?
- Do we make it because we do it cheaper than anyone else?
- Do we do it because there is no-one else out there who can do it more effectively?
- Do we do it because we’ve always done it?
- Do we need to outsource because we don’t have the capacity?
- Do we have the capacity, but are we better served by spending the capital on something else?

7.2 Supply base structure

The supply base is the aggregate of all supplier relationships of the company, and it is also referred in some literature as the supplier portfolio (Bensaou, 1999). Defining the structure of the supply base involves making a decision on the shape that the value chain will have and
will definitely affect the company’s capabilities and business model. Some of the main decisions to be done are listed below;

- Defining the number of suppliers that the firm will have for those products and services that will be outsourced (simple or multiple sourcing).
- Identify who are the main stakeholders and prepare to treat them accordingly.
- Relationship involvement with main stakeholders and others.

As illustrated in Figure 15: Elements to keep in mind when designing the supply base., there are several dimensions to keep in mind when designing the supply base structure. One of the most relevant decisions to be done is, without a doubt, the amount of suppliers that the firm wants to use for those activities that have been outsourced (single or multiple sourcing). This decision is to a large extent connected to the main points highlighted above. There is a clear connection between the extent of involvement with the suppliers and the number of suppliers that are being used (Gadde & Hakansson, 2001, p.156). The reason behind is purely financial, high involvement relationships are very cost and time demanding and most companies cannot afford having too many of them.

When defining the supply base structure a very clear trade-off between dependence and cost appears, and when talking about dependence business risk has to be taken into consideration.
Coming into closer relationships with suppliers (although being initially more costly) can lead to having closer cooperation in the development stage of new product, thus providing VE that can ultimately become significant cost of goods sold (COGS) reduction measures (Mattsson, 2000, p. 223-225). Also the improvement of the communication interfaces (SAP, EDI, VMI, etc.) between the firm and those suppliers where higher involvement is attained can be a cost reduction driver in the long-term.

However, when running into such deep relations with suppliers the dependence of the firm from these suppliers is inevitably increased, thus increasing the risk that decisions from these stakeholders might have severe consequences to the firm’s business performance. Therefore, having too much dependence in a supplier can bring about serious threats from a risk management perspective (Gadde & Hakansson, 2001, p.156-157).

The structure of the supply base can also have a major effect on prices, while having the totality of the volumes concentrated in one supplier (single sourcing) can allow price reductions due to economies of scale, the possibility of leveraging volumes between several suppliers (multiple sourcing) can enhance competition and drive for better prices at the end of the year. In this sense there is no right or wrong supply base structure, every firm needs to find the supply base structure that better adapts their needs and that can bring it to the next level of business performance.

The main advantages and disadvantages of having simple or multiple sourcing according to several authors (Gadde & Hakansson, 2001) (Skjott-Larsen, Schary, Mikkola, & Kotzab, 2007) (Slack, Chambers, & Johnston, 2004) can be observed below.

<table>
<thead>
<tr>
<th></th>
<th>Single Sourcing</th>
<th>Multiple Sourcing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td>- Potentially better quality due to more supplier quality assurance possibilities.</td>
<td>- Price can be driven down by competitive tendering.</td>
</tr>
<tr>
<td></td>
<td>- Durable and stronger relationships.</td>
<td>- Switch of sources is a possibility when supply fails.</td>
</tr>
<tr>
<td></td>
<td>- Greater dependence encourages effort and commitment for each other.</td>
<td>- Wider sources of knowledge and expertise.</td>
</tr>
<tr>
<td></td>
<td>- Better communication interfaces.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Easier to cooperate in new product development.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Scale economies.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Confidentiality</td>
<td></td>
</tr>
</tbody>
</table>
### 7.3 Supplier-buyer relationships

In the Supply Chain many different types of relationship can be developed side-by-side with the different suppliers of the outsourced goods and services. Many different transactions have to be carried out and it is usual that no type of relationship perfectly fits all of them. In fact, suppliers and buyers do with each other a win-lose type of game, where the benefit of the one will in most cases result into a prejudice for the other. The willingness and commitment of both sides to generate win-win (rather than win-lose) situations will define to a large extent the type of supplier-buyer relationship.

At first sight, it might seem that a company should better be highly involved with all its partners. However, developing strong relationships and collaboration is very time and resources consuming (Gadde & Snehota, 2000). Therefore firms face the need to decide with which suppliers they really want to develop strong collaborations and with which partners they prefer to keep more distant relationships.

Understanding what can be the strategic importance and risks of each partner and selecting the right relationship to have with each one is one of the core functions of the purchasing department.

There are different criteria to classify the type of supplier-buyer relationship, the most relevant can be the involvement of the supplier at the development stage of products, the amount of information that is shared, the number and type (e-mailing, phone, videoconferences, face to face meetings) of interactions between the two parties, rights over the intellectual property developed together, timeframe of the relationship, etc. Considering all these criteria, many classifications can be done, but basically two types of supplier-buyer relationship can be distinguished; adversarial and collaborative.

#### 7.3.1 Adversarial relationships

This type of relationship has long dominated the purchasing practice and it is also commonly referred as arm’s length relationship. In adversarial relationships, the buyer typically focuses

<table>
<thead>
<tr>
<th>Disadvantages</th>
<th>Difficult to encourage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Vulnerability to disruption if a failure in supply occurs.</td>
<td>- Less easy to implement quality assurance measures.</td>
</tr>
<tr>
<td>- More effect of volume variations</td>
<td>- More communication effort.</td>
</tr>
<tr>
<td>- Supplier might exert upward pressure on prices if no other sources are available.</td>
<td>- Less scale economies.</td>
</tr>
</tbody>
</table>
only on the immediate price paid for the purchased goods (Skjott-Larsen et al., 2007, p. 233) and gives little importance to other attributes of the relationship.

Due to the fact that price will always be the main decisive factor, no deeper involvement will ever be attained with this type of relationship. While buyers will always try to get the cheapest possible price that brings cost cutting in the short term, suppliers will try to justify higher prices by all possible means, for example loyalty, service level, know-how, etc. These means will obviously be rejected and understimated by the buyer because, as stated before, buyer only focus on immediate purchasing price. Therefore, adversarial relationships usually lead to a continuous state of confrontation between the two parts that execute business transactions.

Arm’s-length relation can have a merit under certain market conditions, for example when purchasing assets with low level of specificity in commodity markets with several players (oligopoly), having an arm’s length relationship with several players of the market can ensure competitive prices due to the direct competition among the different suppliers.

Adversarial relationship imply low involvement and are usually short term relationships, as a consequence there is no need to establish complex communication interfaces between the partners or spend a lot of time in meetings. Thus, in-house costs to handle these relationships are significantly low (Gadde & Snehota, 2000).

### 7.3.2 Collaborative relationships

This type of supplier-buyer relationship is also usually referred as partnership. It implies a higher involvement of the two parts. They are usually long term involvements where there is a basis of mutual trust, openness, shared information and risks and also shared rewards to commonly executed actions (Mattsson, 2000, p.291).

Contrarily to what happens in adversarial relationships, in collaborative relationships both partners have higher commitment on generating a win-win situation for the two parts. On the course of generating this beneficial situation for both sides, long term thinking is needed and also higher investment of resources is required (Gadde & Hakansson, 2001, p.144-145). Partners will have to develop the right communication interfaces and increase the amount of interaction, both in time and number of people involved.

Since purchasing price is no longer the only criteria to consider, other potential benefits of the relationship need to be evaluated by each responsible department of the company. As shown in Figure 16 different departments need to interact, the development departments need to align themselves for the design of new products or for the optimization of current ones, the
respective logistics departments need to communicate so that they can ensure smooth delivery at an optimum cost and the respective management needs to assess whether the overall business partnership is beneficial for each side and generate the needed openness and trust as well as foresee potential risks that might appear in the future and that might hurt the relationship.

Collaborative relationships are generally used with suppliers of complex goods with high degree of specificity. It is necessary that outsourced products to suppliers with collaborative relationships have high volumes (in quantities and in purchasing turnover) and are complex in terms of specification and manufacturing so that there is enough room for generating the savings that justify the higher handling costs of the relationship.

A good summary of the main differences between collaborative and adversarial relationships is presented in by Güthenke & Möller (Güthenke & Möller, Application of price performance analysis in different supplier-buyer relationships, 2011, p.13) and can be seen in Figure 17.

<table>
<thead>
<tr>
<th>Supplier / Buyer relationship</th>
<th>Adversarial</th>
<th>Collaborative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Specific investment between the two parts</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Transfer of information</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Confidentiality of transferred information</td>
<td>High</td>
</tr>
<tr>
<td>Short</td>
<td>Maturity and time frame of contracts</td>
<td>Long</td>
</tr>
<tr>
<td>High</td>
<td>Number of suppliers</td>
<td>Low</td>
</tr>
</tbody>
</table>

Figure 17: Difference in aspects of collaborative and adversarial relationships.
7.4 Fit on the organizational structure

Sourcing is one of the functions performed within the Supply Chain of a firm. However, it is not always the case that procurement is integrated in the Supply Chain department of the company, there are many enterprises that opt for having separated departments for purchasing and supply chain. In such cases, the purchasing department takes care of the relation with suppliers and the SC department covers the actual logistics, meaning the physical flow of materials. In this thesis, purchasing is not only considered to be within the SC department but also accepted as one of the main functions within the SC. The justifications to follow this approach are mainly two;

- As introduced in 5.2.2, BU Installation Systems (IS) has a SC that heavily relies on its suppliers. As explained this is due to the fact that almost 99% of the goods at BU IS are purchased from external suppliers and directly traded to markets. Therefore in BU IS purchasing becomes to a major extent supply management, and this is also reflected in the organizational structure of the company where, as shown in 5.2.2 the function of supply is integrated and closely coordinated with the materials management.

- The second reason has been introduced in 6.1, and it comes from the focus in SCM rather than SC, understanding that SCM encompasses the integration and coordination of all needed operations in the business activity execution, thus the interaction with suppliers being a very important part of it.
8 PRICING IN THE PURCHASING DEPARTMENT

Once the role of supply chain in the firm has been introduced and deeper insights on the role performed by the purchasing department have been given, in this chapter, an analysis of one of the main functions of the purchasing department will be carried out. This function is no other than pricing, or in other words the negotiation and determination of the price to be paid for the goods and services that are outsourced.

First, a definition of pricing will be given. Moreover, all the challenges that purchasers face nowadays and that have significantly affected the complexity of assessing the price that should be paid for a certain good or service will be presented and discussed. Later on, an overview on the implications that pricing might have on each department of the firm will be shown and finally several methodologies to evaluate prices will be presented, among them Linear Performance Pricing will be explained in a further detail and selected to evaluate the price performance of the purchased products at Hilti BU IS.

8.1 Definition of pricing

Pricing can be defined as the activity that regulates and determines which price should be paid for a certain product or service that is transferred between two organizations in the course of a business relationship (Schmidt, 2011). Two organizations that hold a business relationship will have to agree in a transfer price for each of the goods that they exchange in their relationship and these prices will often be bounded to certain boundary conditions and validity time frames.

8.2 The challenge of achieving a good price performance

Obviously, the goal of purchasers is to keep the prices as low as possible, so that they can minimise the COGS of their business area. On the other side, the focus of the sellers will be to increase prices as much as possible so that they can maximise sales and Vertical Gross Margin (VGM) of the products sold. Due to this conflict of interests, it arises the need to establish a parameter to judge how good (cheap) or bad (expensive) a company is purchasing the goods or services that it has decided to outsource, this parameter is referred as the
purchasing price performance (Güthenke & Möller, 2011). A purchasing office will have a good price performance when it is purchasing goods below a certain level of reference, and consequently a bad price performance when purchasing above this reference level. The definition of this reference level is one of the main difficulties purchasers face nowadays and that makes it very difficult to assess what is the right price to pay (Güthenke & Möller, 2011, p.3-5).

In order to exploit the benefits of a price reduction methodology to its maximum level, purchasers need to perform optimization of prices for a wide variety of individual parts for a certain commodity of products. The large amount of parts to analyse requires a lot of time, and therefore a lot of human resources.

In addition to time, there is one more difficulty that purchasers face when judging the price performance, the knowledge gap between the purchaser and the supplier. As previously introduced, there has been a major outsourcing trend along the last decades. This trend has resulted in a lower degree of vertical integration in the value chain of most companies (typically OEMs), and this lower degree of vertical integration ultimately results in a shift of a major percentage of value added to the purchased goods and services (Wildemann, 2000), thus incrementing the dependence of the OEMs from their T1 (tier 1) and T2 (tier 2) suppliers (Gadde & Hakansson, 2001, p.40-45).
Figure 18: Comparison between traditional highly vertically integrated value chains and modern less vertically integrated ones.

This increase on the dependence of T1 and T2 suppliers implies a shift of technological know-how to the suppliers and therefore amplifies the knowledge gap between buyer and seller. This development is overlaid by a significant internationalization of the supply base (Zabota, 2005) which makes it even more complex to assess what can be a good price reference for the purchased parts in each geographic scenario. As a result the tasks of buyers has significantly changed, in addition to business and purchasing knowledge a buyer requires more and more technical know-how (Güthenke & Möller, 2011) in order to understand the complexity of the purchased parts, understand what their main cost drivers can be and ultimately assess the performance of the price that is currently paid or proposed in current references for quotation (RFQ).
As shown in Figure 19: Example of relative cost allocation throughout the supply chain of an outsourced good, a high percentage of the total cost allocation of a certain product will remain at the suppliers and sub-suppliers. The challenges for purchasers is to get as much transparency as possible over this costs so that reasonable purchasing prices can be agreed without allowing the supplier to achieve outstanding margins at the expenses of the purchasing firm. As pointed out in 6.3.2, understanding this cost structure at suppliers and suppliers can be a source of competitive advantage versus competition. Through a better assessment of the cost that a supplier might have, it is possible to achieve better purchasing prices and consequently give the firm a better commercial and financial position towards the competition (Mattsson, 2000, p.205).

8.3 Implications of pricing

As clarified in previous chapters, one of the main responsibilities of purchasers is to negotiate and define the purchasing price for the outsourced goods and services. However, even though this is a clear responsibility of the purchasing department, the implications that a good or bad pricing policy may have fall beyond the boundaries of the purchasing department.
It has been proven that superior Supply Chain Management and more precisely, purchasing, can affect the overall performance of the company (Johnson & Simon, 2011, p.91), (Lambert & Burduroglu, 2000, p.5), but in order to enable this impact on the overall performance of the firm it is necessary that each of the traditional business functions, namely sales, marketing, finance and development, understands the importance of achieving good purchasing price. In this chapter the implications that pricing might have in these traditional business functions is explained. The implications for each of these functions are divided into two main groups, on the one hand, the way they can contribute to achieving a good purchasing price performance, and on the other, the effect that a good pricing performance might have on the individual performance of each department and ultimately of the overall firm.

8.3.1 Finance perspective

Finance refers to the department of the company responsible for monitoring and controlling all the monetary flows that are triggered within the business activity. It is also known as Controlling or Accounting (Joyce, 2006). It consolidates information from different departments regarding cost (operating expenses, purchased goods, etc.) and revenues (mainly sales) and uses it to calculate the different financial KPIs that can ultimately measure the profitability of the business.

Purchasing plays nowadays a strategic role in firm’s profitability and enhanced financial results (Janda & Seshadri, 2001). When a firm has a high percentage of outsourced goods, the impact of the purchasing price of these goods on the balance sheet of the company becomes remarkably high.

Therefore, the major outsourcing trend that many companies have gone through in the last decades has led to significantly increased importance of purchasing, and more precisely, purchase pricing, in the calculation of the bottom line profitability of the company. Increased percentages of the revenues (product sales) that are outsourced also increase the leverage that supply base cost can have on overall financial performance of the firm (Newmann & Krehbiel, 2007). This is the reason why financial controllers need to keep close communication with purchasers to collect information regarding current and future purchasing price development and undertake necessary actions.
Figure 20: Visual Representation of financial KPI to calculate profit.

There are two main KPIs that controllers use to measure profitability; Return on sales (RoS) and Vertical Gross Margin (VGM). As shown in Figure 20 RoS indicates the percentage of the sales that is kept for the firm as benefit (net income), in other words it shows how much of each € of sales stays as benefit for the company and how much is directly passed on to pay the costs.

This costs are partially purchasing cost for the sold goods (COGS) and other costs such as logistics, operating expenses (Salaries, R&D, etc.) taxes, etc. As also seen in Figure 20 VGM is the difference between the net sales price (NSP) or price that the customer is paying for the goods and the Purchasing price that has been payed for the good to the supplier. In the case of VGM other costs are not contemplated.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Full name</th>
<th>Unit</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>COGS</td>
<td>Cost of goods sold</td>
<td>€</td>
<td>( \text{Purchase Price} \times N\text{° of purchased items} )</td>
</tr>
<tr>
<td>RoS</td>
<td>Return on Sales</td>
<td>%</td>
<td>( \frac{\text{Net income}}{\text{Sales}} )</td>
</tr>
<tr>
<td>VGM</td>
<td>Vertical gross Margin</td>
<td>%</td>
<td>( \frac{\text{Purchase price}}{\text{Net Sales Price}} )</td>
</tr>
<tr>
<td>NSP</td>
<td>Net sales Price</td>
<td>€</td>
<td>( \text{What the customer pays for a product} )</td>
</tr>
<tr>
<td>Sales</td>
<td>Sales</td>
<td>€</td>
<td>( \text{NSP} \times N\text{° of sold items} )</td>
</tr>
</tbody>
</table>

Figure 21: Summary table of main financial KPI used in the chapter.

In \( \text{RoS} = \frac{\text{Net Income}}{\text{Sales}} = \frac{750.000}{10.000.000} = 7.5\% \)
VGM = \frac{\text{COGS}}{\text{Sales}} = \frac{5.000.000}{10.000.000} = 50 \%

Figure 22 we can find an example of the financial data of a company that can be used to see how RoS and VGM are calculated.

<table>
<thead>
<tr>
<th></th>
<th>€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net income</td>
<td>750'000</td>
</tr>
<tr>
<td>Sales</td>
<td>10'000'000</td>
</tr>
<tr>
<td>Costs generated</td>
<td>9'250'000</td>
</tr>
<tr>
<td><strong>COGS</strong></td>
<td>5'000'000</td>
</tr>
<tr>
<td>Other costs</td>
<td>4'250'000</td>
</tr>
</tbody>
</table>

RoS = \frac{\text{Net Income}}{\text{Sales}} = \frac{750.000}{10.000.000} = 7.5\%

VGM = \frac{\text{COGS}}{\text{Sales}} = \frac{5.000.000}{10.000.000} = 50 \%

Figure 22: Example for calculation of VGM and RoS.

The conclusion that can be drawn from Figure 20 and Figure 22 is that purchasing price have a very high impact on the financial indicators of the company, and that this importance raises proportionally with the percentage of outsourced goods a company has. Purchasing price has a direct effect on both VGM and RoS. Contrarily to what is generally assumed, the capacity of purchasing price to improve profitability can even be higher than sales.

In Figure 23 a theoretic example of a company with 7.5 % RoS and 50 % VGM is provided. Two different scenarios are then considered, increase of sales by 10 % ( Scenario 1) and decrease of purchase price by 10 % ( scenario 2), the objective is to see how profitability (net income) will vary with each of the scenarios.

<table>
<thead>
<tr>
<th>Company A</th>
<th>RoS</th>
<th>VGM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.5%</td>
<td>50%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>10'000'000</td>
</tr>
<tr>
<td>Net income</td>
<td>750'000</td>
</tr>
<tr>
<td>Costs</td>
<td>9'250'000</td>
</tr>
<tr>
<td><strong>Purchasing of outsourced goods</strong></td>
<td>5'000'000</td>
</tr>
</tbody>
</table>
### Other costs

<table>
<thead>
<tr>
<th></th>
<th>€</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1</strong></td>
<td><strong>δ1</strong></td>
</tr>
<tr>
<td>+10 % sales</td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>11'000'000 €</td>
</tr>
<tr>
<td>Net income</td>
<td>1'250'000 €</td>
</tr>
<tr>
<td>Costs generated</td>
<td>9'750'000 €</td>
</tr>
<tr>
<td>Purchasing of outsourced goods</td>
<td>5'500'000 €</td>
</tr>
<tr>
<td>Other costs</td>
<td>4'250'000 €</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
<td><strong>δ2</strong></td>
</tr>
<tr>
<td>-10 % purchase price</td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>10'000'000 €</td>
</tr>
<tr>
<td>Net income</td>
<td>1'250'000 €</td>
</tr>
<tr>
<td>Costs generated</td>
<td>8'750'000 €</td>
</tr>
<tr>
<td>Purchasing of outsourced goods</td>
<td>4'500'000 €</td>
</tr>
<tr>
<td>Other costs</td>
<td>4'250'000 €</td>
</tr>
</tbody>
</table>

Figure 23: Comparison of the impact of purchasing price and sales on profitability.

As observed δ1 and δ2 have exactly the same development for the two scenarios. As a remark, the figures shown in Figure 23 are theoretical figures, in reality it would be unlikely to increase 10 % sales without having an impact on other cost than the purchased goods and therefore there would ultimately be less than 66 % increase on the net income.

In general, to equal the impact that a cost reduction has in bottom line profit with sales increase, a company needs to increase the sales by a value that equals the savings achieved with the cost reduction divided by the RoS that the company has at the moment.

<table>
<thead>
<tr>
<th></th>
<th>Impact on cash flow</th>
<th>Impact on bottom line profitability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Savings due to reduced prices</strong></td>
<td>€ + 500.000</td>
<td>€ + 500.000</td>
</tr>
<tr>
<td><strong>Revenues due to sales increase</strong></td>
<td>€ + 500.000</td>
<td>€ + 37.500</td>
</tr>
</tbody>
</table>

Figure 24: Impact on bottom line profit of sales increase and of cost reduction.

As shown in Figure 24 in order to achieve the same impact in bottom line profitability than achieved with a cost reduction of 500.000 € the company would need to increase its sales by Achieved savings / RoS , therefore 500. 000 / 0.075 ( assuming same RoS as before of 7.5 %) and that would mean a required sales increase of 6.666,666 € to equal the bottom line profitability of a 500.000 savings in purchased goods.

**8.3.2 Marketing perspective**

Marketing and sales are two departments that are on the other extreme of the value chain. They are in direct contact to the markets and the customers. In the case of marketing the main responsibility is to analyse how the products sold by the company fit to the customer needs.
(Porter, 1985), in other words, identify what is the value proposition (VP) of the product and define the right strategy so that customers finally buy the company’s products.

At first sight, this task seems to be completely separated from the purchasing function, but this is not exactly the case, indeed, together with the definition of value proposition, marketing departments face the challenge of defining what can be the optimum price to sell the products (NSP) (Miller, Hofstetter, Krohmer, & Zhang, 2011). Therefore, marketing departments also face a pricing issue. In this case, though, the matter is to define the selling price (NSP) rather than the purchasing price.

![Figure 25: Variability of NSP with different types of customer.](image)

One of the main rules to keep in mind when defining NSPs is ensuring a good VGM. The problem comes when the products are sold to very different customers, with very different relations to the company and in very different markets. As an example, loyal customers, who purchase a lot since a long time ago from the company, will demand better price conditions than newer or sporadic (cherry pickers) customers. Marketing department need to adapt to this reality in order not to lose customers and this generates a considerably wide span of NSPs that can be used for a certain item. Figure 25 shows how this variance of NSP affects the individual VGM of each transaction. Since there will be a minimum level of VGM that the company needs to maintain it is very helpful for marketing managers to have low purchasing prices of the items that allow them to have big variability in the NSP but still keep VGM within acceptable values.
The opposite situation would be to have a high purchase price. This would have two very bad consequences for marketing managers. First, it would be very difficult for them to compete in price with the competition while assuring an adequate VGM. Secondly, it would reduce their capacity to modify NSP so that they can meet the expectations of different types of customers and as a consequence the company would lose market share.

9 PRICING METHODOLOGIES

Once the importance of pricing in the purchasing department has been clarified, and its relevance for each of the departments in the company has been highlighted, in this chapter several methodologies to assess the purchasing price performance are introduced. Firstly, Linear performance price is explained in detail as an innovative methodology to assess price perfor-
Pricing methodologies in the purchasing department

In a next step, other methodologies are introduced with a general description. Finally, their main strengths and weaknesses are indicated and discussed.

### 9.1 Linear Performance Pricing

Linear performance Pricing (LPP) is a statistical methodology that aims at establishing a mathematical correlation (regression) between the prices of a set of purchased products (family or commodity) and one or more properties that characterize the purchased parts (Güthenke & Möller, 2011, p.4). Therefore the functionality or technical value of the parts is explained by a set of parameters, also called drivers or explicative variables.

The ultimate objective of the methodology is to compare the functionality or the technical value of different parts of the same family with the purchasing price paid for each of them and therefore two main kinds of input data is necessary; purchasing prices and explicative variables. Once the data is collected a scattered plot can be drawn, in Figure 26 the Y-axis is representing the purchasing price for the different parts while on the X-axis the technical value or functionality determined by the chosen explicative variables is given.

![Figure 26; Example of scattered plot obtained in LPP analysis](image)

It can be observed that an average line divides the area in cheap and expensive parts, furthermore the group of items that shows a better price performance can also be aligned together to define what will be the benchmark line. In order to improve the price performance of the commodity all parts should be as close as possible to the benchmark line.
In order to explain the method in a more visual way, the commodity “screws” is selected. There are millions of different screws that can be purchased in the market, with thousands of different potential suppliers and with different prices for each of them. In order to analyse the price performance of each purchased screw we define the variable weight as the explicative variable for the price paid. In Figure 27 the scattered plot that is obtained can be observed when relating the weight of each screw with its purchasing price. The trend line in the scattered plotted is obtained by following the traditional single regression formula;

\[ \text{Purchasing Price} = a_0 + a_1 \times \text{Weight} \]

\[ \begin{align*} 
45 \, \text{€} & \quad \text{Expensive} \\
40 \, \text{€} & \quad \text{Screw A} \\
35 \, \text{€} & \quad \text{Trend Line} \\
30 \, \text{€} & \quad \text{Cheap} \\
25 \, \text{€} & \quad \text{Purchasing price (€)} \\
20 \, \text{€} & \quad \text{Weight (g)} \\
15 \, \text{€} & \quad \text{0} \\
10 \, \text{€} & \quad \text{50000} \\
5 \, \text{€} & \quad \text{40000} \\
0 \, \text{€} & \quad \text{Weight (g)} \\
\end{align*} \]

Figure 27; scattered plot of purchasing price in relation of weight of screws

In this formula \( a_0 \) and \( a_1 \) are the coefficients that determine the minimum price that can be paid for a screw of weight zero and the steepness of the trend line respectively. It can be observed that this line divides the graph in two areas; above the trend line are the screws that are purchased too expensive. Oppositely, below the line are the screws that are being purchased at a good price level. It is noted that the randomly chosen Screw A appears to be too expensive according to its weight.
9.1.1 The insufficiency of single regression

The problem of applying such a methodology using single regression is that the items that are too expensive according to one of the explicative variables might be on the average line or even on the benchmark line when the commodity is analysed according to another explicative variable. Thereby, it is impossible to assess the price performance of the parts because the results that are obtained solely rely on the chosen explicative variable. In Figure 28 and Figure 29 the purchasing price of the same commodity “screws” is analysed but in this case the variables length and strength (more precisely tensile strength Rm of the raw material) are taken as explicative variables. It can be observed how the purchasing price performance of the screw varies depending on the explicative variable that is chosen to analyse it. In this way, according to the weight, Screw A is an expensive screw. It becomes a cheap screw when being analysed according to its length, as observed in Figure 28 and it is on the average line when analysing it according to the Rm of its raw material as it can be seen in Figure 29.

![Scatter plot of purchasing price in relation to length of the screws](image-url)
The need to consider several variables when assessing the price performance of technical purchase parts can be solved by using multiple linear regression. By doing so, all the variables that are considered to be relevant for the functionality or technical value of the purchased parts can be taken into consideration.

The challenge of applying the multiple regression is that we have a number of variables which is higher than 2 and therefore it is not possible to represent it in a flat (2D) scattered plot. For this reason, the parameter technical value is defined as the value or functionality that each piece has for the purchaser and that can be calculated with the explicative variables that are considered to be relevant. For example, for the previously used commodity of screws the following formula would be used to calculate the technical value of each screw.

\[
\text{Technical value (€)} = a_0 + a_1 \times \text{Weight (g)} + a_2 \times \text{Length (mm)} + a_3 \times \text{Rm (N/mm2)}
\]

It is important to note that the technical value is a parameter that has no unit per se. However, from a theoretical point of view it can be understood as the economic value that the purchaser is willing to pay for the goods and therefore its unit can be the same as the purchasing prices that are being used, namely €.
As it can be observed in Figure 30 Product A and Product B would be showing different price performances when analyzed according to two different variables. The challenge is to set the coefficients of the explicative variables ($a_0, \ldots, a_N$) so that the overall price-value distance is minimized, this is a computing task that is done following the method of the least squares. Once the technical value is defined for each of the purchased parts, the LPP analysis can be done for the commodity assuming that as many cost variables as needed can be taken into consideration to assess the overall price performance of the purchased parts.

### 9.1.2 Catalogue parts and drawing parts

It is important to distinguish between drawing parts and catalogue parts. When the purchased item is based on a drawing that is provided by the development department of the purchasing firm, no freedom to design the part is given to the supplier. Therefore, the method needs to be re-adjusted by selecting parameters that explain why a certain item is more or less expensive. The used raw material, the number of steps required in the manufacturing process or the needed temperature for the surface treatment process are examples of possible parameters that explain the cost breakdown of a certain item. These parameters are known as cost drivers or cost explicative variables.

On the other hand, catalogue parts are those parts that are offered by the supplier on its standard catalogue. The parts define its functionality or performance by a set of attributes that justifies why the customer should pay more or less money for them. A typical example of a cata-
Pricing methodologies in the purchasing department

Logue product are cars, their functionality can be explained by numerous variables, for example power (hp), maximum speed (km/h), maximum capacity load (Kg) or number of passengers that can drive on it. These properties characterize the functionality of the parts and therefore its performance or value added for the buyer (Newmann & Krehbiel, 2007).

9.1.3 Application of Linear Performance Pricing

The necessary steps to apply Linear Performance Pricing (LPP) are described in Figure 31. It is important to mention that the methodology cannot be applied on a one direction sequential manner. Instead, it needs to be applied as an algorithm where several iteration loops are needed to reach the optimum point. These iterations will mainly affect the definition of the parts involved in the model and the selection of the drivers. These two steps often need to be recalibrated due to the fact that they are crucial to achieve a robust model that can be validated both from a statistical and pragmatic perspective. Unfortunately, the validation of the model and assessment of the results can only be done on a later step and therefore it is often necessary to go some steps back and retouch the model in order to achieve a robust model that allows us to derive valid conclusions.

![Figure 31: Main steps to consider when applying LPP (Güthenke & Möller, 2011)](image)

Once the main steps have been introduced and its sequence has been presented a deeper look into each of the steps is done.
9.1.3.1 Definition of part families

In this first step the parts that will be analyzed on a certain commodity are selected. The parts that are analyzed in the same model should be similar in terms of functionality or manufacturing technology. LPP provides the possibility to put different parts under direct comparison, in other words, LPP allows comparing oranges with apples, but it is still important that parts that can be modulated under the same set of variables are kept within the same group. Summing up, and continuing with the previous example, LPP allows comparing oranges with apples with a high chance of achieving valid conclusions, but the chances to achieve valid conclusions are dramatically reduced if we try to compare oranges with fishes. Hereby the need to select the right parts in each model.

One of the important things to define at this stage is whether the studied group of parts (commodity) is a catalogue part or a drawing part. The implications of each case have already been described in chapter 9.1.2 and they will have an important effect on the type of drivers that will be selected in the next steps.

9.1.3.2 Identification of drivers

In this second step, the set of parameters that explain the functionality or technical value of the purchased parts is selected. In the case of catalogue parts, the selected drivers will have a connection to the product functionality or performance. On the other hand, when purchasing drawing specific parts, cost drivers related to the raw material used or the manufacturing technology and processes need to be included in the analysis. In Figure 32 some examples of catalogue parts and drawing parts are provided and possible variables to use in a LPP analysis are also pointed out.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Possible Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drawing parts</strong></td>
<td></td>
</tr>
<tr>
<td>Cold formed steel parts for a car engine (designed by the purchaser’s R&amp;D department)</td>
<td>Raw material (Carbon/Stainless Steel, grade), n. of stamping operations, welding needed, surface treatment</td>
</tr>
<tr>
<td>Transistors for the CPU of a laptop</td>
<td>Weight, needed amount of Silicium, Max. Temperature in the production</td>
</tr>
</tbody>
</table>
As it can be observed in drawing parts it is important to select drivers that can assess the manufacturing costs, thus it is important that experts from the development and the purchasing department come together in order to find the right cost drivers that indicate the real technical value of the parts. It is also important at this stage to assess possible functional correlations among different variables.

In the case of drawing parts, the selection of the right drivers does not only allow a proper calculation of the technical value but also provides information regarding the impact of each variable in the ultimate cost of the parts. This information can be very valuable for the design of future parts since a higher focus can be given to those parameters that prove to have a significant effect on price.

9.1.3.3 Collection of data

Once the commodity groups have been defined and the explicative drivers for each of them have been selected it is the moment to proceed to collect the data. Basically, there two groups of data that needs to be collected; the data values for each of the selected drivers for each of the part in a commodity and the current purchasing prices for these parts.

The collection of the data for the selected drivers can be done internally. In the case of drawing parts the engineering department should be able to provide all the data regarding the specifications of the product. Indeed, in a drawing part the engineering department has been the responsible for the design of the part and therefore, it should be no problem to collect any data regarding required product specifications. Also communication with suppliers might be necessary in order to better understand what the needed manufacturing process for each part is. In this regard, having a collaborative relationship with suppliers is a big advantage in order to get full transparency and collect the necessary data in a more efficient way.

The second block of data to collect is the current purchasing price of the analyzed parts. Although it might seem that this information should be easy to collect, there are many disturb-
Pricing methodologies in the purchasing department

Changes in the invoiced prices that disguise what the real purchase price for a part is. Since LPP analysis compares the product technical value with its economic value it is important to separate any costs related with logistics, development, settled discounts and tooling investments and depreciations.

9.1.3.4 Analysis of the data

Once the data has been collected, multiple linear regression is used to describe the correlation between the products technical value and the purchase price. As already mentioned in previous chapter this is a computing task done by software that applies the least squares methodology and provides the coefficients for the selected values. Modern statistic software can also eliminate the negative effect that linearity among drivers could have on the validity of the model so that any set of variable can initially be used.

The target will be to select the drivers set that maximizes the linear correlation between the technical value and the purchasing price. This implies that not all the drivers that had been selected in the second step (selection of drivers) will finally be part in the model.

The usage of the statistic software makes it easy to try how the regression coefficient of determination ($R^2$) changes depending on the selected set of variables. Thereby, a set of drivers that generate a model with a high correlation can finally be selected. In Figure 33 it can be observed how the obtained scattered plot price - technical value changes depending on the set of selected variables and also how the linear correlation is affected. In the first plot no clear linear correlation is observed ($R^2 = 0.38$) while in the right plot there is a clear linear correlation between the technical value determined by the selected set of variables and the purchasing price of the parts ($R^2 = 0.83$). The second model would be the suitable set of drivers to proceed with the LPP analysis.

![Figure 33](image-url)
9.1.3.5 Validation of the result

Before starting to derive measures that can be applied in following price negotiations it is necessary to validate the model. This validation needs to be done from two perspectives; statistic and technical.

**Statistic validity**

The usage of LPP implies the creation of a multiple regression model. While the iterative process and algorithm needed to generate the model and the average line are done with software, it is still necessary to pay attention to certain statistic parameters so that statistic validity can be given to the model. The statistic parameters that need to be considered are the following:

- **Number of data points**: indicates the total number of parts that are considered in the model. There is no specific minimum number of points but there should be enough points so that convincing results can be achieved. For example, it would make no sense to arise conclusions from a model of three points.

- **R square (R²)**: also referred as coefficient of determination. It explains how good or bad the linear fitting between the technical value and the purchasing price is. In this way a high R² implies high linearity and oppositely a low R² implies lack of linear correspondence between technical value and price. In general, it is necessary to achieve a minimum R² = 0.80 to give statistic validity to the model.

- **Adjust R square (Adj R²)**: it is a modification of R² that takes into consideration both the number of data points and the number of cost drivers, increasing only in case that a new driver improves the model more than it would do only by chance. In general, it would be enough to assure the value of R² but in models with a very reduced number of data points and a large number of cost drivers it is necessary to crosscheck that Adj R² is also above 0.80.

- **F-test (or simply F)**: is a probability value related to the F test that is done when determining the coefficient for each of the explicative variables. Low significant F indicates that high confidence level to reject the null hypothesis that all coefficients are 0. F should be always below 0.05 so that a confidence level of 95% can be guaranteed.

**Technical validity**

The technical validity refers to the acceptance that the model makes sense at the eyes of an expert. Unlike the statistic validity check, the technical validity does not use parameters provided by the statistic software but empirical observations of the equation and scattered plot...
that have been generated. The check list to validate a model from the technical perspective is the following:

- *Negative coefficient;* if negatives coefficients appear in the function, the model needs to be questioned from the technical point of view. A negative coefficient implies that a lower price is expected for higher functionality or technical value. This could be possible or valid but it needs to be questioned whether it really makes sense from a technical expert point of view.

- *High/low functionality outliers;* parts that have a functionality or technical value which is extremely high or low compared to the rest of parts in the group are considered outliers and should be excluded from the analysis. Their impact on the regression is too high and therefore these points hide possible conclusions that could be extracted from the rest of parts. In Figure 34 the effect of their elimination is illustrated.

![Figure 34; Elimination of an outlier due to extremely high functionality in a LPP analysis](image)

- *Non-homogeneity;* sometimes, even if the definition of commodities has been done in very precise way, different product families have been included in the same model and two small scattered plots can be observed in the graph. In Figure 35 an example of this situation can be observed. When this occurs there is a need to question whether the two subgroups really should be in the same model. Usually it makes sense two separate the two groups and analyze them separately because more precise and reliable conclusions can be achieved. However, it is also possible to leave the two sub-groups in the same model and try to understand what the parallelisms among parts of the two groups are. When the two sub-groups are left in the model special attention needs to be given to the statistic validity of the model.
9.1.3.6 Derivation of measures

Once the model has been validated, it is the moment to identify potentials for savings and derive the necessary measures so that these savings can be achieved. The first step in order to identify the savings is to identify a benchmark line; this line is used instead of the regression line. Using the regression line would only target to bring the product to the average line of price-performance ratio, the benchmark line defines more ambitious targets by doing a second regression with the 20% parts with a best price-performance ratio. In Figure 36 the blue line is the benchmark line obtained from the multiple regression of the 20% parts with a better price-value performance. On the detail in the right the difference price levels that are obtained (part price (reference), average and benchmark) are illustrated.

Figure 36; definition of benchmark line and detail of the different price levels that are obtained.

Once the different price levels have been identified for each of the parts it is the moment to focus on the gaps or differences between the prices that are currently paid and the benchmark price. It is important to analyze the type of gaps because depending on the nature of the gap
different procedures are applied to achieve the savings potentials. Two main different kinds of gaps can be observed;

- **Commercial gap:** this is the price difference that appears between two parts with very similar technical value. In general, these price differences come from inflated prices by the supplier and the measure to tackle them is usually through direct negotiation. The way these commercial gaps are discussed with the supplier(s) depends on the supplier-buyer relationship. In case of collaborative relationship it is possible to openly discuss them and either close the gaps by price reduction or shift the volumes to another supplier who is able to reach the same technical value with less cost (better technology, cheaper labor work, etc.)

- **Technical gap:** these price differences appear due to unclear or undefined specifications regarding the functionality or the manufacturing process of the parts. It is often the case that developers design parts without really bearing in mind the implications that their final design can have in the manufacturing process of the part. When big technical gaps are identified it is important to make a deep dive in the parts that hold the gap and analyze what are the differences in their manufacturing processes. Once these differences are identified, the necessary changes in the manufacturing can be applied so that the gap with the benchmark line can be closed. If the current supplier is not able to adopt the proposed changes, the purchaser can consider shifting the part to the supplier who already is in the benchmark line.

### 9.2 Other methodologies

After LPP has been explained in detail as a modern methodology to assess price performance of purchased parts, in this chapter, two more traditional methodologies will be presented. The objective is to discuss their main strengths and weaknesses so that later on the right methodology can be selected for a couple of real business cases. These two methodologies are Total cost of ownership (TCO) and Cost Breakdowns.

#### 9.2.1 Total Cost of Ownership

Total cost of Ownership (TCO) is another method to calculate the cost of outsourcing a certain product to an external partner. TCO can be defined as a structured approach for determining the total costs associated with the acquisition and subsequent use of a given item or service from a certain supplier and delivered to a certain market. (Mattsson, 2000, p.368).
TCO has a lot of similarities with Activity Based Costing (ABC). For example, TCO tries to allocate the different costs that are generated whenever a transaction is executed by following all the needed actions in this transaction and calculating the overall cost that the transaction leaves behind.

The main difference with other methodologies, like LPP, is that TCO does not focus on the purchasing price of the outsourced parts. More precisely, TCO is a methodology that includes all the costs that arise from executing the purchasing transaction from a certain supplier. As a consequence, purchasing price of the parts is one of the aspects considered in TCO but not the only. In Figure 37; Example of the structure of a TCO calculation an example of a TCO calculation for a certain product is displayed, and the main cost generators that are observed within the transaction are illustrated:

As it can be seen in Figure 37; Example of the structure of a TCO calculation there are two main trams where the costs can be allocated, from the supplier to the distribution warehouse and from the distribution center to the customer site. The main cost generators are the following:

- **Transport**: accounts for the costs that needs to be paid for transporting the goods from supplier to the warehouse (inbound) and then from the warehouse to the customer (outbound).
- **Taxes and duties**: the costs that arise from the payment of taxes and import duties to the countries that the goods go through. Depending on the locations, it is often the case that they need to be paid double when the warehouse, supplier and customer are in three different countries.
- **Tooling**: costs that arise from tooling investment and maintenance to produce the parts at supplier.
- **Warehousing**: costs of keeping the inventory. It is often estimated as percentage of the value of the goods (e.g. 15%)
- **Capital costs**: impact on the cash flow that the investment of capital has during the throughput time of the goods along the supply chain.

Total Cost of ownership is considered to be suitable methodology to analyse competence of supply sources but not assess purchasing price performance. Therefore, it is considered very suitable to us TCO in combination with LPP. While LPP can help in estimating the purchasing prices, TCO can be used to assess the rest of costs that arise within the purchase transaction.

### 9.2.2 Cost Breakdowns

Another methodology that can be used to assess the performance of the purchasing price for outsourced goods is what is commonly known as Cost breakdowns. The underlying concept in this methodology is to learn from the supplier what the main cost generators in the manufacturing of the parts are.

This methodology implies having a collaborative relationship with the supplier because trust and transparency is needed between the two parts. In case, an adversarial relationship is given it is very unlikely that the supplier is willing to show where the costs lie, and furthermore quantify the value of these costs for different product groups and families, or even in an item level.

![Figure 38; Example of cost breakdowns calculation for a certain product group.](image)
As shown in Figure 38: Example of cost breakdowns calculation for a certain product group. All the aspects that add costs to the production of a certain product can be considered. Therefore, the purchase of raw material and needed components (screws, etc.), production and assembly, needed treatment to finalise the product, packaging and logistic overheads are included in this calculation and the supplier should provide the data regarding the amount of money paid for each of them so that at the end it can be estimated what is the supplier’s benefit margin and assess whether it is considered adequate.

An advantage of this methodology is the possibility to learn from the product cost structure and take measures in the cost generators that imply most of the cost and therefore can ultimately generate more COGS savings.

On the other hand, achieving such a level of transparency can be very time and resources consuming, first to build up the relationship to a level where the supplier is willing to share the data and secondly to verify, crosscheck and monitor this big amount of data. Another potential drawback of using cost breakdowns is that in unfavourable circumstances (e.g. raw material price increase in the global market) the space for negotiation is very reduced. Since there is such a high level of transparency, the supplier is likely to use it to pass on these circumstances directly on to price increases. In this case the purchaser has no room for reaction, because questioning the legitimacy of the impact on costs of the new situation would jeopardize the whole model that has been previously agreed.

9.2.3 Comparison of methodologies

The following chart aims to be a direct comparison of the main strengths and weaknesses of the methodologies that has been previously presented. The objective is to set the basis to justify the selection of one methodology that will later on be applied in two real business cases.

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
</table>
| Linear performance pricing| - It provides transparency on the price performance based on the parameters that are relevant to the purchaser and that can be gathered internally in the company.  
- Relatively quick to execute once | - It requires frequent communication with R&D in most of the steps of its execution.  
- Conclusions can be raised internally, but no reference for competition prices is taken into |
<table>
<thead>
<tr>
<th></th>
<th>data has been gathered.</th>
<th>consideration.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Conclusions can be derived on different levels; item, family, supplier, technology.</td>
<td>- Technical knowledge of purchasers is highly appreciated.</td>
</tr>
<tr>
<td></td>
<td>- Illustration of the result is very visual and a strong argument in negotiations.</td>
<td>- No information regarding total cost is given, only purchase price.</td>
</tr>
<tr>
<td></td>
<td>- It can be used on quotation checks of new or special parts.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Learnings on cost structure can guide COGS savings projects.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Cost of Ownership</th>
<th>- It provides a broad overview of all the costs involved in the transaction.</th>
<th>- It does not provide information regarding the purchase price, which is one of the main contributors to the total cost.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Gives transparency on the cost structure that products leave behind along the supply chain they go through.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost breakdowns</th>
<th>- Provides full transparency to supplier costs and margins.</th>
<th>- Very time consuming to build up relationship and monitor data.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Learning on cost structure can guide COGS savings projects.</td>
<td>- Room for negotiation is much reduced once the model has been fully implemented.</td>
</tr>
</tbody>
</table>
10 BUSINESS CASES

Arrived to this point, the importance of purchasing and, moreover, the importance of the purchasing price in companies with a high degree of outsourcing has been described in detail. In addition, several methodologies have been described on how to assess the performance of the prices paid and a comparison among them has been done.

Among the described methodologies, a major focus has been given to Linear Performance Pricing (LPP) due to the fact that it is a relatively modern methodology and that not so much research has yet been done about it.

In this chapter, LPP is selected to evaluate the purchasing price performance of the outsourced goods in large company of the construction industry. As it has been introduced in chapter 5.2, Hilti AG is the company where this study has been realized, more precisely in the purchasing department of the BU Installation Systems.

As introduced in chapter 9.1 the first step to do in the application of LPP is to categorize the different products to analyze in different product families or commodities whose technical value or functionality can be modeled using the same set of explicative variables. The products purchased at Hilti BU Installations have been described in chapter 5.2.1, in this chapter three main products groups have been described; channels, pipe rings and components.

In order to apply LPP, the same classification is going to be used. However, LPP will only be applied for two of them; pipe rings and components. These two business cases are considered sufficient to crosscheck the applicability of LPP and verify if it is a good methodology to achieve superior price performance.

10.1 Components

The commodity of components is made up with all the parts that are used to connect the installation channels with each other and also with pipe rings or other boundary elements (walls, floor, etc.). These parts are made of steel and are cold formed by different suppliers according to the drawing that has been developed by the R&D department. This is the first important thing to keep in mind; the parts in this commodity are drawing parts. This implies that the supplier receives a technical drawing with several specifications and is free to decide how he wants to manufacture the parts. In Figure 39 several images of items of the analyzed commodity components are illustrated.
10.1.1 Identification of drivers

The first thing to keep in mind when defining the explicative variables is the fact that this is a commodity of drawing parts. As a consequence, it is important to identify which drivers can indicate the technical value of the parts, in other words, drivers that indicate how difficult, and ultimately how expensive, it is to manufacture the parts. The set of drivers that is selected to model the technical value of the commodity components is the following:

- **Material**: this variable identifies the raw material that is used for the part. Noticeably, this is not a numerical variable. Instead, it will be a categorical variable that can take the following values.

<table>
<thead>
<tr>
<th>$X_{material}$</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Carbon Steel</td>
</tr>
<tr>
<td>1</td>
<td>Stainless Steel</td>
</tr>
</tbody>
</table>
As an initial approach only these two values are considered. However, on a second step it is also possible to consider the grade of the steel. In this way, in case the analysis is split in two models because very different technical values are observed for carbon steel and stainless steel parts, the variables $X_{\text{carbon steel}}$ and $X_{\text{stainless steel}}$ could also be added.

<table>
<thead>
<tr>
<th>$X_{\text{carbon steel}}$</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>S 355 JR</td>
</tr>
<tr>
<td>1</td>
<td>S 235 JR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$X_{\text{stainless steel}}$</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A2</td>
</tr>
<tr>
<td>1</td>
<td>A4</td>
</tr>
</tbody>
</table>

- **Weight**: this variable represents the amount of mass in the finished good. It is a numerical variable measured in grams (g). Another possibility that have been taken into consideration is to consider the weight of the total input raw material needed in the manufacturing process, thus including the weight of the scrap generated during the production. However, this option has been disregarded since it is considered a task of the supplier to minimize the amount of scrap in the production so that the costs, and ultimately the prices can be as competitive as possible. Therefore, the variable that will finally be used is the weight of the final piece in grams.

- **Number of stamping operations**: this variable represents the number of stamping operations that are needed to manufacture the piece. Stamping is a metal-sheet manufacturing process that includes several operations such as punching or blanking. The underlying concept is to form sheet-metal steel applying pressure on the steel with a dice that has a predesigned form in order to create shaped wholes or setoffs in the steel sheet. Therefore, the number of required stamping operations is calculated by visual observation of the parts, counting the number of wholes and setoffs that can be seen. This number is the maximum number of stamping operations that could be needed. In case the supplier uses its manufacturing know-how to produce the part with less operations it will have an effect on the “cost-technical value” ratio of the part.

- **Number of bending operations**: this variable represents the number of bending operations needed to manufacture a part. Bending is the manufacturing process that allows changing the direction of a metal sheet by applying pressure on the coil. This variable
is also calculated through visual inspection of the part, counting the number of required changes of direction in the surface of the metal sheet. Once again, if the supplier manages to produce the part with less operations it would lead to better technical value—cost position for him.

- **Length of welding:** this variable considers the length of the trams of the piece that needs to be welded. Whenever two parts of steel need to be attached it will be done with a welding wire. By adding up the length, in mm, of this wire this variable can be calculated. In Figure 40 two examples of how to calculate the variables number of stamping operations, number of bending operations and length of wire welding are provided. The red lines represent the welding wires and the blue lines represent the axis that the surfaces are bended around. Stamping operations is calculated counting the number of wholes.

![Figure 40](image)

Figure 40: two examples of how the variables are calculated in commodity components.

- **Surface Treatment (ST):** this variable models the impact that the surface treatment chosen for a part has on the technical value of the part. In general, four different cases for the surface treatment of the parts can be considered. The carbon steel parts can be finished in galvanized (zinced), hot dip galvanized (HDG) and hot dip galvanized plus (HDG+). In addition, the stainless parts have no surface treatment. The main difference between these treatments is the different thickness in the layer of zinc that they provide that prevents corrosion of the piece. Therefore, the variable ST will be modeled as a qualitative variable that can take the following values.
Pricing methodologies in the purchasing department

<table>
<thead>
<tr>
<th>Surface treatment</th>
<th>$X_{\text{zinced}}$</th>
<th>$X_{\text{HDG}}$</th>
<th>$X_{\text{HDG}+}$</th>
<th>$X_{\text{none}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinced</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HDG</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HDG +</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The statistical validity of the model is sometimes affected when including categorical variables of more than two categories. Therefore, in the event that problems to validate the model are observed, this variable can be turned into a numerical variable by considering the thickness of the layer of coating that each surface treatment implies. This would be measured in $\mu$m. In this way the variable would take the following values.

<table>
<thead>
<tr>
<th>Surface treatment</th>
<th>$X_{\text{thickness coating}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinced</td>
<td>15</td>
</tr>
<tr>
<td>HDG</td>
<td>55</td>
</tr>
<tr>
<td>HDG +</td>
<td>75</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Thickness (mm):** this variable represents the thickness of the sheet of steel that is required as a raw material. When a coil that is 2 mm thick is used, not only the raw material is cheaper due to less material, but also it is easier to form the parts because less power and less sophisticated tools and machines are needed. This variable is calculated by direct inspection of the parts and measuring the thickness of the metal-sheet in mm.
- **Volumes (pcs/year):** this variable counts the number of pcs that are purchased during one natural year. There are two main purposes for including such a variable. On the one hand, analyze the possible effect of economies of scale and on the other to categorize the item in an ABC analysis to see if different price levels are being offered for A, B or C items.

10.1.2. Analysis of the data and validation of the result

Once the commodity is defined and the cost drivers are identified, the next logical step is to collect the data. However, this step has no real academic value, and therefore no chapter is
dedicated to it. As stated in the description of the variables, the collection is done in many cases by direct visual inspection of the parts or by using information available in the company’s data warehouses. The complexity of collecting the data will heavily depend on the quality of the data management that the company counts on.

Therefore, the next step to do in the application of LPP is to generate the model and analyze what can be the right set of drivers for it. Later on, the model will have to be validated. The generation of the model is done by uploading the database that has been collected (in Microsoft excel) to a statistical analysis software. In this case, Analycess Procurement Lite is used to generate the model. The model that is generated can be observed in Figure 41.

![Figure 41; initial LPP model for commodity components using all variables.](image)

It is noted that the values in the vertical axe cannot be provided due to confidentiality issues with the company where this thesis has been carried out. This rule applies for the rest of figures of LPP analysis that will be illustrated in this paper.

As it can observed, from the first point of view certain linearity can be observed between the technical value that is calculated and the purchase price. Nevertheless, a closer look is taken into the statistic parameters for the model as well as the multiple regression equation that has been obtained.
Taking a look at these values several conclusions can already be extracted;

- The values of $R^2$ (and also Adj -$R^2$) are above the 0.8 that is defined as the minimum to consider a good enough linear correlation between the technical value and the price. Therefore, the set of drivers that was assumed as driver for technical value can now be validated as good indicators of how complex a part is, and therefore, how much the company should pay for it.

- Taking a look at the coefficients that have been obtained for the multiple regression equation it is also possible to extract some conclusions. For example it can be appreciated that there is no impact of the yearly volume on the purchased price (coefficient =0) and therefore no effect of economies of scale is at the moment observed for this commodity.

It is also possible to observe that in general a higher price is paid by those parts that are produced in Stainless Steel. This can be observed by looking at the coefficients in the equation ($X_{\text{materialcarbon}} = -0.2731$ and $X_{\text{materialstainless}} = 0.2731$) but also when applying a filter in the graph in order to distinguish the stainless and the carbon steel parts. This different trend can be observed in Figure 42 where the red line shows the average for the blue highlighted points that represent (as shown in the legend) the parts that are made of stainless steel. Since there is a big difference between the benchmark line for stainless and carbon parts it might make sense to divide the model in two, one model for parts of stainless steel and one model for parts of carbon steel. The models obtained can be seen in

- Figure 43 for carbon parts and Figure 44 for the stainless parts.
Figure 42; LPP model for commodity components with differentiation between carbon steel and stainless.

Figure 43; LPP model for commodity components only for carbon parts.
By splitting the model in two, the linearity and statistical validity of the model have changed and therefore it needs to be crosschecked once again. The table below summarizes the values for the carbon steel model.

<table>
<thead>
<tr>
<th>Obtained Regression equation Carbon model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Value [€] = 0.5804 + 0.0026 * X_{bending} + 0.0075 * X_{stamping} + 0.1419 * X_{welding} + 0.0023 * X_{weight} + 0.0213 * X_{thicknesscoating}</td>
</tr>
<tr>
<td>( R^2 )</td>
</tr>
<tr>
<td>Adj -( R^2 )</td>
</tr>
<tr>
<td>F-Test</td>
</tr>
<tr>
<td>Data points</td>
</tr>
<tr>
<td>Variables</td>
</tr>
</tbody>
</table>

It can be observed that the linearity has significantly improved. It is noted that now the categorical variable of material is no longer in the model because it adds no information since all parts have the same material.
In the table below, the indicators for the stainless model are shown. In this model also a better linearity compared to the original model is observed. The categorical variable material has also been removed and, in this case, also the thickness of the coating has been removed as a variable since stainless parts have no surface treatment at all.

<table>
<thead>
<tr>
<th>Obtained Regression equation stainless model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Value [€] = 0.3989 + 0.0994 * X\textsubscript{bending} + 0.3727 * X\textsubscript{stamping} + 0.0667 * X\textsubscript{welding} + 0.00664 * X\textsubscript{weight}</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( R^2 )</td>
<td>0.932</td>
</tr>
<tr>
<td>( \text{Adj} - R^2 )</td>
<td>0.928</td>
</tr>
<tr>
<td>F-Test</td>
<td>0.0001</td>
</tr>
<tr>
<td>Data points</td>
<td>44</td>
</tr>
<tr>
<td>Variables</td>
<td>4</td>
</tr>
</tbody>
</table>

The statistical validity of the two models can be approved at this point. However, a pragmatic crosscheck needs to be done on the parts that are showing extraordinary high or low technical values. These parts are known as outliers and once they are detected it is important to check the part in the “real world” in order to verify whether it makes sense from a technical point of view to include them in the model. Some candidates to be an outlier have been pointed out with the red arrows in Figure 43 and Figure 44.

In the case of the outliers observed in the carbon model that showed really high technical value a crosscheck was done with the development department and it turned out that those were parts that had not been cold formed. Instead they were produced by casting. Therefore, the technical value of this parts could not be modeled with none of the variable used (they are not stamped, welded, etc.) and it makes sense to exclude them from the model. Although this outliers are no longer considered in the model they raise awareness regarding two factors,

- Possibility of starting another model for all those purchased casted parts.
- Casted parts show in general worse price performance than cold formed (outliers were way above the benchmark line).

10.1.3 Derivation of measures

The two models (stainless and carbon) for the commodity components have at this point been validated from technical and statistical perspective. Therefore, it is possible to extract valid conclusions that can be used to reduce the prices for the purchased prices. The first step will
be to set characteristics on the parts so that we can visually check in the model whether there is any specific trend. The first characteristic that will be analyzed is the supplier of the parts. In Figure 45 the model for carbon parts can be observed with a characteristic color for each supplier were the parts are purchased.

The conclusions that can be observed in Figure 45 are the following:

- Supplier B (blue boxes) is providing the parts with a highest technical value and therefore also with a higher price.
- Supplier C (red diamond) shows the best price performance, since its parts are aligned with the benchmark line for the 205 parts with a better price performance.
- The fact that many parts are concentrated in the lower technical value are of the graph suggests that a deep dive in that part of the graphic might make sense.

In order to get an idea of the magnitude of savings that the negotiations with each supplier can bring, the total potential savings per supplier is calculated. This can be calculated in the following way.

\[
\text{Savings potential}_{\text{Sup.} A} = \sum_{i=0 \ldots n} (\text{Purchase Price}_i - \text{Benchmark price}_i) \times \text{Yearly volume}_i
\]

Through the application of this formula the software can provide us with Figure 46 where it can be observed that biggest potential for savings can be achieved with Supplier B. It is observed that for Supplier B the gap between the current annual purchasing
volume (APV) and the optimal is the biggest and therefore all efforts should initially be concentrated with him.

Figure 46; Identified potential savings per supplier for commodity components.

The strategy to achieve these potential savings is defined by the type of gaps that can be observed between different parts in the model. As explained in 9.1.3.6, there are mainly two types of gaps; commercial and technical. The case of Supplier B in commodity components is a very good example of commercial gaps.

In Figure 47 a zoom into the part of the graphic where most of the Supplier B parts lay can be observed. The vertical lines in the graphic enable us to identify parts with very similar technical value (see red bubbles) that despite having this proximity in technical value show remarkable price differences. If this phenomenon was observed among parts that are sourced in different suppliers it would likely that the two suppliers are using different practices (leaner plant, modern technology, cheaper labor cost, etc.). But what can be observed in Figure 47 is different groups of parts sourced at the same supplier, with similar technical value and significant price differences that can be justified with any of the reasons exposed above because all
the parts are manufactured in the same facilities (same technologies, same know-how, same labor cost, etc.)

Figure 47: Zoom into the area where most of the Supplier B parts lay.

The action plan to achieve the identified potentials savings includes presenting the results to Supplier B. On this matter, it is much more beneficial to have a long term collaborative relationship (see 7.3.2) with the supplier because it increases its predisposition to sit and discuss on the results obtained. The concrete measures to improve the price performance of commodity components would be the following:

- Schedule a negotiation with Supplier B and openly discuss the results obtained.
- Challenge Supplier B with the price differences observed on items that happen to have similar (or even identical technical value) and that are all purchased at him.
- It is likely that for some of the parts, Supplier B is able to come up with explanation why certain prices are more expensive. It could be that some factor that has an impact on price was not taken into consideration by any of the selected drivers and therefore it is not appreciated on the technical value of the part.
- For those parts were no justification for the price difference is found Supplier B needs to adjust the prices so that the gap between current price and benchmark price can be closed.
- In order to put more pressure on the negotiation RFQs (references for quotations) will be asked to other suppliers. Observing Figure 47; Zoom into the area where most of the Supplier
it can be seen that Supplier C provides very good price performance so it would be the first candidate to quote.

- Since a very low impact of the yearly quantity has been observed on the price it is possible to use economies of scale as an argument to strengthen the negotiation.

### 10.2 Pipe Rings

The next commodity that is selected to be analyzed using the LPP method is the commodity pipe rings. Pipe rings are used to fix and hold pipes that provide different types of supplies to buildings. Pipe rings are normally made up with two semi rings made of steel that can be separated from each other in order to allocate the pipe in their center. In addition, pipe rings incorporate some kind of protection between the steel and the pipe. This is intended to protect the pipe from being damaged and also for insulation purpose (both thermal and noise insulation). Another of the key features of pipe rings is the closing mechanism they use to lock themselves once the pipe has been installed inside the rings. In Figure 48 several examples of parts of the commodity pipe rings are shown.

![Figure 48: several examples of parts in the commodity pipe rings](image)

The pipe rings purchased by Hilti BU Installation Systems are also designed by Hilti engineers and produced by different suppliers. Thereby, commodity pipe rings is again a commod-
ity of drawing parts and the set of drivers that is used for this model needs to represent the technical value of the parts.

Figure 49: Pipe rings once they have been installed in a supplying system.

10.2.1 Identification of drivers

The set of drivers that is selected to calculate the technical value of the parts involved in the commodity pipe rings are the following.

- **Material:** this variable is exactly the same that has been explained in the commodity components. It is a qualitative variable that can take the values of 1 (stainless steel) or 0 (carbon steel). Also in this case several grades can be considered on a second step exactly the same as in commodity components.

- **Maximum clamping diameter:** this is a quantitative variable that represents the maximum diameter of a pipe that can be clamped by a certain pipe ring. This variable is measured in millimeters (mm) and is part of the specifications of the product that can be observed in the technical drawing provided to the supplier.

- **Weight:** this variable is also the same that has been used in the commodity components. It considers total weight of a finished pipe ring and it is measured in grams (g).

- **Insulation:** as mentioned in the introductory paragraph of this commodity, one of the main features of pipe rings is their capacity to insulate sound and temperature from the pipe. In the case of Hilti pipe rings mainly two types of insulation are offered using two different types of rubber, EPDM rubber and a second more sophisticated rubber that is internally known as EPDM 2. This variable is obviously a categorical variable that can take the following values.
### Insulation

<table>
<thead>
<tr>
<th>Insulation</th>
<th>$X_{\text{epdm}}$</th>
<th>$X_{\text{epdm2}}$</th>
<th>$X_{\text{none}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPDM rubber</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>EPDM 2 rubber</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Surface Treatment**: this variable would be exactly the same as the variable of the same name that has been introduced and used in the commodity components. All explanations can be found in chapter 10.1.1.

- **Closing mechanism**: this variable is a categorical variable that represents the mechanism used to lock the two half rings of the pipe rings once the tube or pipe that they sustain has been allocated into the rings. In Figure 50 the three types of closing mechanism used in Hilti pipe rings are illustrated.

![Figure 50; Different types of closing mechanism for Hilti pipe rings.](image)

The importance of this feature is that it eases a lot the mounting and clamping of the pipe rings. It is important to keep in mind that usually pipe rings need to be installed in high places with not so good accessibility and little capacity to maneuver for the operator. Therefore, this is understood as a comfortability and safety contributor, but it also has an implication on the cost structure of the manufacturing process.

- **Volume**: this variable represents the number of parts purchased per year at the supplier. Identically as in the commodity components it helps to model the impact of economies of scale as well as to categorize items according to a Pareto ABC model.
10.2.2 Analysis of the data and validation of the results

As it has been explained for the commodity components, the data collection is a step that is no considered of no academic value and therefore the next step to proceed is the generation of the model and its consequent analysis and validation.

Once again, using the software *Analycess Procurement Lite* the regression model for the commodity pipe rings can be generated. In the case of commodity components, it has already been learnt that carbon steel and stainless steel are much better analyzed in different models because the price development for each of them is remarkably different. Therefore, in commodity pipe rings carbon and stainless are also studied separately. In Figure 51 the model that is obtained is shown.

![Figure 51; LPP model obtained for the carbon steel pipe rings.](image)

It is possible to observe certain linearity in the model, however there seems to be a range of outliers (red bubble) that appear to have a drastically high purchase price for their technical value.

As shown in the table below, the model does not reach the minimum level of linearity ($R^2 = 0.56$) and therefore some things need to be changed. In order to do so, first the impact of each of the variables is analyzed.

- By looking at the regression equation it can be observed that, in this case, there is a significant impact of the yearly quantity, therefore it is considered suitable to leave this variable in the model.
- Weight and maximum clamping diameter show a high influence in the technical value and therefore in the purchasing price of the parts.
- The closing mechanism also shows a high influence on the price, more precisely the double screw mechanism shows a very high influence on the price compared to the crocodile and even more compared to the one screw mechanism.
- A very high influence on the price is also observed for the “Insulation”, pipe rings with the rubber inlay show in general a higher purchase price.
- Finally, in the case of pipe rings the influence of the thickness of coating is also perceptible but not as much as it has been observed for the components.

<table>
<thead>
<tr>
<th>Obtained multiple regression equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Value[€] = 2.37 - 0.0003 * X_{yearlyvolume} + 0.0021 * X_{weight} + 0.1535 * X_{diameter} - 0.8101 * X_{None} + 0.8101 * X_{EPDM} + 0.0209 * X_{thicknesscoating} + 1.0849 * X_{Doublescrew} - 0.8922 * X_{onescrew} - 0.1928 * X_{Crocodile}</td>
</tr>
</tbody>
</table>

| R² | 0.56 |
| Adj -R² | 0.543 |
| F-Test | 0 |
| Data points | 532 |
| Variables | 6 (2 categorical of 2 and 3 categories each) |

- Technical feasibility of outliers:
The technical feasibility of including the group of outliers that is highlighted in red in Figure 51 in the model needs to be discussed. When taking a look into which items form this group of outliers there is one common characteristic to all of them; they are parts that have the two widest diameters that are offered in the standard portfolio of pipe rings. This is the main outcome that can be extracted by internal discussion within the firm. On a next step, when presenting the results to Supplier C (supplier for this parts) the supplier explains that for such wide diameters it is not possible to do the automatic assembly of the parts, hence they need to be manually assembled and therefore the costs raise considerably. Therefore, this is a clear case of technical gap where the difference in the technology used is implying a very significant price gap.

These outliers are, therefore, excluded from the model because it has been learnt that their cost structure is not comparable to the rest of pipe rings were automatic assembly is possible. The fact that they are excluded from the model does not mean that no measures are derived
for them. In the next chapter, the measures to adopt for this group of pipe rings are described with detail.

Another possibility to analyze the technical feasibility of the model is to set characteristics that define different types of products. In the case of product there is a classification for the pipe rings that stems out from the marketing department and that refers to the application that each product group can fulfill. The pipe rings can be divided in the groups that can be observed in Figure 52. As it can be observed the pipe rings Residential and Light Duty show are perfectly aligned with the benchmark line, they offer the best price-performance ratio.

Figure 52: LPP model obtained for the carbon steel pipe rings once the outliers have been removed and with characteristic set at product type.

The better price performance of Residential and Light Duty can be crosschecked with the marketing managers and field engineers that better know what the applicability of these parts is and how it differs from other parts. When asking them, they can confirm that since they are used for applications with lower stress loads they can use thinner material; hence the raw material price and the complexity of the manufacturing are much cheaper. However, it is not possible to achieve the required loads for other application (e.g. industrial) with such a thin
material and therefore it is not possible to apply this learning to the more expensive product groups *Heavy duty* or *Ventilation*.

The product families *Light duty* and *Residential* are also excluded from the model in order to achieve a more homogeneous comparison of parts. Once again, this does not mean we cannot derive conclusions for them. In fact, we already learnt the reason why they are cheaper and that this cannot be applied to more expensive groups but in order to achieve more realistic results it is better to analyze them in a separate model.

In Figure 53 the obtained model when all the outliers have been is shown, this is the final validated model to work with for the LPP analysis of heavy load carbon steel pipe rings from which measures can be derived.

![Figure 53: Final LPP model obtained for the carbon steel pipe rings split by product family](image)

The table below summarizes the main statistical indicators for this model;

<table>
<thead>
<tr>
<th>Final obtained Regression equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Value[€] = 2.88 - 0.024 * X_{yearlyvolume} + 0.0171 * X_{weight} + 0.1820 * X_{diameter} - 0.701 * X_{None} + 0.701 * X_{EPDM} + 0.0212 * X_{thicknesscoating} + 1.053 * X_{Doublescrew} - 0.912 * X_{one screw} - 0.156 * X_{Crocodrile}</td>
</tr>
<tr>
<td>$R^2$</td>
</tr>
</tbody>
</table>
### 10.2.3 Derivation of measures

In the validation and analysis of the data of commodity pipe rings many of the measures have already been indicated. For example, for the bigger diameters it has been observed that manual assembly implies higher costs, or that for certain product families lower requirements in the stress loads lead to reduced costs.

In order to get an idea of the whole picture, so that measures with higher potential of savings can be prioritized the total potential savings for each supplier is calculated. As explained in 10.1.3 the potential savings per supplier can be calculated as:

\[
\text{Savings potential}_{\text{Sup. } A} = \sum_{i=0 \ldots n} (\text{Purchase Price}_i - \text{Benchmark price}_i) \times \text{Yearly volume}_i
\]

And when applying this formula to the model obtained for the pipe rings the results observed in Figure 54. Supplier A has now disappeared of the model because it was only supplier for *Residential.*
Taking a look at these results it is easy to observe that the highest identified potential appears for Supplier C and therefore the first measures will be to discuss the results with him.

The list of measures that are derived for supplier C is the following;

- Discuss the possibility of investing on a new machine for the automatic assembly of the widest diameters that were identified as outliers in Figure 51. The potential savings of such an investment can be calculated by using the benchmark level that the automatically assembled pipe rings provide. Once this potential savings are calculated, they can be directly compared to the needed investment and management can decide if the payback of the operation is worth or not.

- As shown in Figure 55 many vertical lines are observed for parts of supplier C. Obviously this type of graphs is due to the fact that many qualitative variables are used in the model, but it is also true that very wide ranges on the purchase price are observed for parts with same technical value. As a measure of pressure in the negotiation to close this commercial gaps it can pointed out that a second supplier (B) is usually at the bottom of this vertical lines, although supplier B receives a much lower number of parts and of turnover.
For Supplier B the following measures would be taken:

- Firstly, it needs to be discussed with Supplier B if they have the technical feasibility to automatically assemble the big diameters that supplier C cannot. In case, they can do it the parts can be directly shifted without the need of an investment.

- Furthermore, the results obtained can be shared with the supplier. It might seem that since they are already in a very good price position for many parts it is not good to show them the results. However, this results can be used as an stimulator for them to let them know that they are currently on the benchmark line and that they should offer the same price level in future quotations.

- Offer Supplier B the possibility to quote those parts where they offer better price performance than supplier C although technical value is the same or very similar.

Finally, for the case of commodity components there are some important findings that need to be shared internally in the company, especially with the development department;

- It has been observed a much higher impact on price of the closing mechanism *double screw*. When it has been crosschecked with suppliers the outcome has been that more components are needed and more time for assembly is needed when compared to for example the *crocodile* system.
Since the *crocodile* system is already regarded as the best from a value proposition point of view (easier and faster to install while maintaining similar load capacity), it is advised to avoid the *double screw* mechanism for future designs because it implies higher costs and no significant advantage.

10.2.3.1 Quotation check

The usage of LPP in the commodity pipe rings also has one more application. Pipe rings are offered in several sizes, closing methods and insulations in the standard catalogue. However, it is often the case that markets require a tailor made pipe ring with a certain size, weight or locking system which is different from any of the pipe rings offered in the standard catalogue. In this case it is possible to use the equation that has been obtained from the model so that a reference purchase price can be achieved for this “special” pipe ring. The values of $X_{(1…n)}$ for the requested pipe ring should be introduced in the equation and a technical value would be achieved, with this technical value a benchmark and an average price can be retrieved from the model.

\[
\text{Technical Value}\left[\text{€}\right] = 2.88 - 0.024 * X_{\text{yearlyvolume}} + 0.0171 * X_{\text{weight}} + 0.1820 * X_{\text{diameter}} - 0.701 * X_{\text{One}} + 0.701 *
X_{\text{EPDM}} + 0.0212 * X_{\text{thicknesscoating}} + 1.053 * X_{\text{Double screw}} - 0.912 * X_{\text{One screw}} - 0.156 * X_{\text{Crocodile}}
\]

This learning can be applied in any commodity where engineered-to-order parts are often required since it provides visibility to the cost drivers and it speeds up the process to check how good or bad a quotation is.
11 CONCLUSIONS

In this paper the role of the supply chain and more precisely, of the purchasing department has been analyzed. In addition, a closer eye has been taken to the purchasing price of the outsourced goods and several methodologies have been presented that enable to judge the quality of the price performance for outsourced goods. Subsequently, LPP has been selected to perform a purchasing price performance analysis on two commodities of a large firm of the construction sector with a high degree of externalization.

The reason for this recapitulation of the whole paper is to justify that the conclusions that stem out of this thesis can be classified mainly in two levels; on the one hand, conclusions related to the role of the supply chain and more precisely the purchasing function in the firm, and, on the other hand, conclusions related to the applicability and implications of the application of LPP.
Regarding the role that the purchasing function plays in the company the following conclusions can be taken out from this paper;

- Purchasing is a strategic function of the company that can heavily influence the firm performance since it has a direct influence on product performance and on financial indicators.

- The strategic importance of sourcing is proportional to the percentage of goods that are outsourced. In other words, the more a company decides to purchase goods outside its boundaries, the more important it will be to have a superior purchasing level that enables good product and price performance in the outsourced goods as well as a possibility for the rest of the departments to focus on what has been decided to be the company’s core competence, hence enabling competitive advantage.

- Top management should invest necessary resources and give sufficient priority to purchasing so that all needed projects and actions can be executed. Even though, operations are generally seen as less fancy compared to marketing, sales or development it has been proven that investing resources in sourcing pays off.

- The strategic importance of purchasing is enhanced in tough crisis environments were the need to compete in costs is crucial for companies to stay competitive.

- Purchasing should not operate as an isolated department in the company. Contrarily, it has been observed that, ideally, sourcing should act as a corner stone with other departments such as marketing or development because the cost awareness that purchases hold can be very valuable in future parts design and in defining adequate market prices.

Finally, regarding the applicability of the LPP in the purchasing department and its benefits the following conclusions are observed;

- LPP is a good methodology to assess the price performance of purchased parts and can be used achieve superior price performance.

- LPP provides visibility on the price performance of individual parts. In addition, it is also possible to assess performance on a supplier level, family level or any criteria that is estimated necessary. Therefore, LPP guides the purchasers towards the right direction where measures are needed.

- The probabilities to succeed in the application of the measures that stem out of an LPP analysis heavily rely on the supplier-buyer relationship. The results obtained need to
be shared and discussed with the supplier and this implies that the supplier needs to be willing to listen and learn from the conclusions of a model.

- Considering the previous point, LPP is most likely a successful methodology when collaborative long term relationships are hold with suppliers. In adversarial situations it is very unlikely that the supplier wants to sit to discuss the model.

- The learning regarding the cost drivers that stem out of an LPP analysis give a very good picture of what is generating cost in the purchased parts. This information should be shared with development department to optimize cost of future parts.

- LPP is useful in environments where many engineered-to-order parts are needed because it provides a good reference for quotations of “special” parts.

- Although an LPP analysis should normally be led by a purchaser, it is very beneficial to make continuous workshops with developers and product managers. These workshops are made in order to define product commodities and drivers but also to understand and apply the leanings regarding the cost structure of the purchased parts.

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