

Total Cost of Ownership for Global sourcing: Application to a Mechatronic New Line

The case study of a German Automotive Company

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Abstract

Under study is a German automotive worldwide company, belonging to the first tier of suppliers, which keeps continually seeking for improvements on their performance, as with innovative products, or with development and improvement of their functions along their supply chain. It is within this context that this study is implemented, considering a new and innovative mechatronic product with the goal of increasing its attractiveness through offering a lower final price. To achieve this goal, the company under study decided to improve their purchasing function, making a strategic move towards its globalization. In this paper will be studied the current Total Cost of Ownership (TCO) tool used by the , evaluating its applicability for global sourcing activities and the possibility for global sourcing from a cost reduction perspective, suggesting specific part groups with highest potential for savings and regions to source.

Key words: Global Sourcing, Purchasing Strategy, Supplier Selection, Total Cost of Ownership

1. Introduction

'It is the maxim of every prudent master of a family, never to attempt to make at home what it will cost him more to make than to buy [...]. If a foreign country can supply us with a commodity cheaper than we ourselves can make it, better buy it of them with some part of the produce of our own industry, employed in a way in which we have some advantage.' (Adam Smith, 1776, cited from Holweg et al., 2011).

Nowadays, markets are changing fast and becoming more and more competitive. The pressure on companies is increasing and making them pursuing ways to become more cost efficient. Their necessity to reinforce its competitive position on the market is higher.

The role played by purchasing departments in the companies is gaining more importance in the cost reduction measures, leading purchasing managers to seek solutions to the current situations, in order to improve these departments' performance. In the globalization of their activities, companies find ways to achieve competitive advantage, sometimes resorting to global sourcing. The current economic recession shows little evidence of reversing this trend; in fact, this will likely increase the pressure to source globally (Hultman et al., 2012).

"If companies that have developed a new product do follow a country-by-country approach to foreign market entry over time, a globally oriented competitor will likely overcome their initial competitive advantages by blanketing the world markets with similar products in shorter period of time" (Kotabe and Murray, 2004).

Global sourcing is one the greatest challenges that managers need to face, experiencing the need to ship their sourcing activities

from local suppliers to low-cost countries suppliers (Hultman et al., 2012) and it was in this precise context that the motivation for this work appeared at the company under study, where the work has been developed. The challenge proposed by the company consists in developing a global sourcing strategy for the new product line at company's Mechatronic Products, including concrete recommendation for part groups with highest benefit potential from this strategy, in order to decrease the price per piece.

1.1 Research Objectives

This study aims to contribute to the studies related to the application of Total Cost of Ownership tool to global sourcing activities. At the moment, the goal of the company was to start global sourcing activities for the Mechatronic project, and for that, would like to know if the Total cost of ownership, *Sourcing Decision Sheet*, used by the department would be feasible for these activities. In addition, an evaluation of new sourcing markets with an indication of possible savings for each region. For this evaluation was important to create a complete understanding how the purchasing function was working, in order to be able to fully understand the tool under study.

This paper is organized as follows: section 2 provides the relevant literature review, section 3 presents the methodology developed to reach the objectives, section 4 the methodology developed in section three is applied and the results are commented, lastly in section 5, conclusions are made on the results achieved.

2. Literature Review

2.1. Developments in Purchasing

Over the past century, major developments occurred regarding with firm's purchasing strategy. Purchasing departments gained more importance among the firm's structure and became

responsible for larger share of business units (Gadde et al., 2010). According to Gadde et al. (2010), purchasing transactions no longer can be seen as isolated, but from a total cost perspective, while purchasing price is not the only decision-making factor, where the need to consider transactions costs related with logistics, legal and production is highly evident.

Choi and Hartley (1996) compare the materials flow with the pressure “movement” through the supplier chain, showing that while materials flow through the supply chain towards the OEM’s, pressures flow on the other way around from OEM’s towards indirect suppliers, proving the increasing competitiveness while going down the supply chain positions. Quintens et al. (2006b) points to the fact, that as a reaction to this increasing competitiveness, companies are changing their position on supply chain, engaging on global sourcing activities with the main goal of achieving competitive advantage. The global sourcing approach is described hereafter.

2.2. Global sourcing

2.2.1. Definition

Companies are turning more and more their supply chain lean, so as to increase their competitive advantage and as a result of that, outsourcing activities are increasing (Choi and Hartley, 1996). However, it is not clear from literature the understanding on this topic, since it varies from author to author and from firm to firm. Quintens et al. (2006b) highlight this fact underlining the fact that six different names are given to similar international behaviors, such as global sourcing, international purchasing, worldwide sourcing, import sourcing, offshore sourcing and international procurement. Quintens et al. (2006b) and Bozarth et al. (1998) suggest a definition of global sourcing as an activity that involves “searching and obtaining goods”, “services” and other possible resources worldwide.

Kotabe and Murray (2004), Agndal (2006) and Neureiter & Nunnenkamp (2009) suggest that the firm’s global sourcing strategy is a key to successful development and production of the firm’s major products and components. They define global sourcing as “logistical management of the interfaces of R&D, manufacturing and marketing activities on a global basis”. It is also stated that different firm’s parts, located in different geographic points should align their processes in order to achieve a successful global sourcing. When for Araujo and Gadde (2009) the motivation for engaging in global sourcing can be seen as resulting from both the managers’ “efficiency-seeking” ambitions and their “recipe-following” behavior.

Global sourcing for intermediate products or components usually occurs in two different ways: (1) from their foreign subsidiaries or parents on an “intra-firm basis” and (2) from independent suppliers on a contractual basis (Kotabe and Murray, 2009). Nassimbeni and Sartor (2007) suggests, from an evaluation of ten Italian firms, that we can consider three types of sourcing: *sourcing imposed*, *sourcing intermediate* and *direct sourcing*, establishing a direct relation between the type of sourcing with company size, complexity of the product and company structure, so large companies should engage on direct sourcing which involves direct relations with suppliers, confirming the purchasing strategy of the company.

Quintens et al. (2006a) states that the conceptualization of the purchasing process should happen in four phases: markets research, supplier selection, negotiation and contracting and finally supplier evaluation.

2.2.2. Motivators and Barriers

Kotabe and Murray (2009) present a list of pros for outsourcing and another against outsourcing. In this list, arguments in favor of global sourcing and arguments against it are presented. In favor, is possible to point out strategic focus and reduction of assets, strategic flexibility, avoidance of bureaucratic costs and relational rent. Against, there are interfaces and economies of scope pointed out, hollowing out, opportunistic behavior, rising transaction and coordination costs and limited learning and innovation. Agndal (2006) believes that firms do not follow any single pattern for

expanding in international purchasing, although a few factors can be used to analyze their actions. Motives, triggers, and attitudes are the most important of these factors. According to Araujo and Gadde (2009), early outsourcing trends which were mainly in pursuit of efficiency, and later cost reduction, were later widely expanded in terms of both scale and scope. This initiated outsourcing processes that many managers began to follow, but with less attention to performing thorough and rigorous analysis of whether or not these efforts would pay off in terms of efficiency.

Holweg et al. (2011) presents a table (Figure 1) which summarizes the points in favor of global sourcing found in previous literature, and its respective evolution through the same literature. The pitfalls are mainly cost related, and they point out long lead-times, transport costs and custom duties as well as cultural differences and communication problems.

Monczka and Giunipero (1984)	Monczka and Trent, 1991	Nassimbeni (2006)
<ul style="list-style-type: none"> • Lower prices • Firm had worldwide operations and attitude • Availability of foreign products • Improved quality of foreign products • Technology available from foreign sources • To fulfil countertrade/offset/local content requirements • Due to developing worldwide competition • Improved delivery of foreign product 	<ul style="list-style-type: none"> • Cost reduction • Quality improvements • Increased exposure to worldwide technology • Delivery and reliability improvements • Introduction of competition to the local supply base • Establishing a presence in a foreign market • Satisfying offset requirements • Increase the number of available sources • Reacting to the offshore sourcing practices of competitors 	<ul style="list-style-type: none"> • Purchase materials and components at lower costs • Achieve resources not available in the home country • Possibility of acquiring less expensive manpower • Global competition • Global attitudes of the company • Possibility of acquiring advanced technologies • Reduction of commercial barriers • Possibility of developing a presence on foreign markets • Presence of plants in foreign countries • Possibility of selling products on supplying markets • More favourable taxation

Figure 1- points in favor of global sourcing (Holweg et al, 2011)

Horn et al. (2013), develops the concept “ugly twins” which is applicable to cases when global sourcing fails. He states that the results of a bad sourcing decision can represent high impacts on costs when dealing with global sourcing. Usually the solution is to source the product from a local supplier. This change needs to occur as quicker as possible, forgetting some important aspects regarding with the product and supplier performance, and usually with higher costs. To these types of contracts they call “ugly twins”. They suggest that to avoid situations less favorable when sourcing globally, an extra attention should be paid. However Nassimbeni (2006) suggests that supplier selection process when dealing with global suppliers can be similar with the one applied to local suppliers, this statement comes from their sample analysis, where concluded that supplier selection criteria for local suppliers are applied to global suppliers. The buyers’ dependence on the suppliers’ resources increases, which makes it even more vital for the buying firms to be able to analyze supplier performance (Handfield and Nichols Jr., 2004).

Handfield & Nichols Jr. (2004) suggest that in order to make a good judgment when suppliers are to be selected for new products, buying firms must consider the type of product, so supplier selection reveals itself as an important variable on global sourcing function, and their study is elaborated below.

2.3. Supplier Selection

With the increase of the importance of purchasing function, as an activity that produces value, supplier selection became one of the most substantial function performed by the purchasing department and “Supplier selection problem has become one of the most important issues for establishing an effective supply chain system” (Tahriri et al., 2008; Boer et al., 2001). Tahriri et al. (2008) states that supplier selection aims to help companies achieving JIT Productions by reducing the purchase risk, maximizing overall value to purchaser, developing closeness and long-term relationships between purchasers and suppliers. Choi and Hartley (1996), in an early study regarding supplier selection, analyzed some supplier selections processes from a selection of US firms,

and identified four goals with their supplier management during the entire supply chain: faster delivery, decreased production lead time, reduced cost, and increased quality. They defend that selection of suppliers should be based on their "potential for a cooperative, long-term relationship", and this principle is as important for final assemblies as to direct and indirect suppliers. Price is also presented as one of the least important variables during the selection process.

Later studies, formulated the concept of Supplier Management Orientation (SMO), adding more variables to supplier selection function. Shin et al. (2000), relates SMO with Supplier Performance (SP) and Buyer Performance (BP), attributing aspects to take into account to each of the variables. Regarding with SMO they identify "long-term supplier-buyer relationships", "supplier involved in product development", "quality focus in selection suppliers" and a "reduced supplier base"; for BP aspects related with product are considered like performance, features, reliability conformance and durability as for SP general aspects regarding with performance are considered as "cost", "quality", "delivery reliability", "lead time" and "on time delivery". An improvement on buyer and supplier's quality and delivery was achieved with this approach, but flexibility failed to be achieved and when cost reduction is one of the main goals, other methods should be endorsed. Focusing on how companies select suppliers at different supply chain levels (tiers), Choi and Hartley (1996) identified eight factors: finances, consistency, relationship, flexibility, technological capability, customer service, reliability and price.

Supplier selection can be viewed as a multi-criteria decision making, affected by several and not linear factors. Trade-offs between criteria must be analyzed by managers and they adopt a long-term perspective (Ferrin and Plank, 2002; Tahiri et al. 2008). Degraeve and Roodhooft (2000) point supplier's selection criteria such as net price, quality, delivery, performance, historic record, capacity, communication system and service, geographical location. There are several supplier selections methods available in the literature and supplier selection processes differ among the auto industry (Choi and Hartley, 1996; Tahiri et al. 2008). Boer et al. (2001) suggests two different supplier method's characterization, qualitative methods and quantitative methods. Qualitative methods affect the first two phases of the purchasing process: problem formulation and problem criteria; quantitative methods focus on qualification phase and final selection. The main focus will be on the last two phases, qualification and final selection, which represents bidder's lists and approved vendors, and quotation analysis and order allocation, respectively, however, the success of these final phases directly depends on the success of the first phases. For these final phases five main decision models are identified: linear weighting models, total cost of ownership models, mathematical programming models, statistical models and artificial intelligence based models (Boer et al., 2001). Based on the scope of this study, only total cost of ownership (TCO) models will be considered.

2.3.1. Total Cost of Ownership

According to Boer et al. (2001) "TCO-based models attempt to include all quantifiable costs in the supplier choice that are incurred throughout the purchased item's lifecycle", and according to Ellram and Siferd (1993) "TCO requires firms to consider the activities they undertake that cause them to incur costs". Ellram (1995b) states that some aspects like order placement, research and qualification of suppliers, transportation, receiving inspection, rejection, replacement, downtime caused by failure and disposal costs can be considered on a TCO approach, as Wouters et al. (2005) confirms nearly the same, affirming that TCO assess all the cost activity related, separating the costs considered into two main categories: purchasing related and quality related.

Activity Based Costing is "a management account methodology that aims to assign costs to the activities that generate costs" (Ellram, 1995c). TCO is based on Activity Based Costing (ABC) with a particular difference: TCO costs need to be captured by supplier by item; so a good understanding of the process flow represents an advantage to implement a successful TCO analysis (Ellram, 1995b; Ellram and Siferd, 1993). Degraeve and Roodhooft (2004) state that savings generated from ABC is representative,

even though purchasing activities do not yield value added, once they are depending on supplier performance.

From the purchasing process point of view, Ferrin and Plank (2002) identify three major perspectives for the valuation of TCO approach. First they suggests that cost must be considered on a long-term perspective, second, they point that purchasing managers must consider the costs created by different business functions on specific purchasing process and thirdly, managers should understand the impact of all activities associated to the entire purchasing process.

2.3.2. TCO as a supplier selection tool

Degraeve and Roodhooft (1999b) claims that supplier selection has become "one of the most critical activities of a company in today's competitive business world", and state that a wrong choice of a supplier can result on significant "operational and financial problems for the purchasing company". From this perspective, TCO appears as a plausible solution for dealing with this pressure, offering a good data overview regarding with supplier performance, facilitating the negotiation with suppliers and their respective selection and evaluation, creating a comparative advantage for those companies which do not use this approach (Ellram, 1995b).

From previous experience, firms learned that selecting a supplier from the lowest bid is not the correct selection, once usually lower prices hide lower qualities, and is based on this concept that TCO appears as a good tool to assess, as best as possible, these trade-offs (Ellram and Siferd, 1993). Ellram and Siferd (1993) point that empirical studies revealed some achievements in cost reductions while using TCO approaches while Degraeve and Roodhooft (1999a) achieved savings in order of 11% when applying TCO to a Cockerill Sambre S.A purchasing project.

Degraeve and Roodhooft (2000) identify several advantages while applying an ABC to supplier selection models such as: (1) facilitates the quantification of criteria and their trade-off assessment, (2) assess costs systematically, (3) enables firms to develop inter-organizational activity based management opportunities, (4) allows answers to questions regarding with cost management and strategic decision making.

2.3.3. Benefits, Barriers and Motivators

Ellram (1995b) identified some barriers and some motivators to the TCO approach, stated in available literature and confirmed on case studies. Table 6 summarizes the achievements made by Ellram (1995b), these factors are interrelated and their understanding is essential to ensure an efficient adaptation of the current strategy to global sourcing strategy.

2.3.4 Cost Drivers

Costs can be seen as "direct versus indirect" and "variable versus fixed" and they are characterized based on their behavior through the entire purchasing process (Ellram and Siferd, 1993). Ellram and Siferd (1993) identified six major groups for cost drivers, while later, Ferrin and Plank (2002) developed those cost drivers into thirteen major cost drivers group (Table 2).

However some developments have been made between these two approaches. Holweg et al. (2011) proposes a cost classification into 3 categories: static costs, hidden costs and dynamic costs, avoiding for the fact that, within a global sourcing strategy the risks of misleading cost calculations can happen, due to the unforeseen hidden and dynamic costs, increasing the risks.

Table 1- Motivators, Barriers and Benefits for TCO approach (source Ellram, 1995b)

Motivators	Barriers	Benefits
Support supplier selection process, assisting RFQ analysis, such as for new suppliers or selecting from supplier pool	High application time, increasing purchasing process time	Consistent supplier evaluation tool, improving supplier performance comparisons among suppliers over time
Awarding suppliers on their performance recognition	Lack of costing data available	Clarify/define supplier performance expectations both in the firm and supplier
Conduct supplier developments	Situation-specific costs, which leads to a high variation of the TCO costs for an item-specific purchase	Create major opportunities for cost savings by focusing on areas in which supplier performance would be most beneficial
Keep up with process changes	Mentality change from price orientation to total cost understanding	Improves perception of supplier performance issues and cost structure
Forecast supplier performance	TCO models adapts to each firm, varying widely	Provides excellent data for negotiations
Assess current supplier performance		Opportunity to justify higher initial prices based on better quality/lower total costs
Help negotiations, providing essential data		Provides a long-term purchasing orientation
Anticipate new item performance		
Concentrate attentions on a specific purchase		
Benchmark offers		
"support strategic alliances efforts"		
Reduction of the supply base		

2.4. TCO and Global Sourcing

There are few literary evidences correlating Global sourcing and TCO approaches. However, the existing ones confirm the high and advisable applicability of this approach while dealing with outsourcing activities.

Ellram (1995a) suggests the TCO approach as an "excellent approach for understanding the true cost implications of the outsourcing decision, rather than focusing on price". When considering cost reduction as a main goal, it is of the manager's best interest to have a clear picture of the cost related with the outsourcing process (Ellram, 1995a). Webber et al. (2010), confirms what previously was stated, saying that TCO approach creates a "methodological framework", when dealing with outsourcing activities. Even though in this case, savings were achieved when performing global sourcing, it also highlights the fact that this results are case-specific, not being possible generalize. Lan and Zhang (2006) developed a framework to support outsourcing decision-making identifying three cost outsourcing drivers categories: Economic factors, Strategic factors, and environmental factors, alongside with obstacles like lack of

capable service suppliers, loss of control, poor transportation, IT infrastructure and local protection regulations.

As a result of the application to a specific outsourcing case, Ellram (1995a) identified two roles for the TCO approach: (1) the TCO approach enables to identify the areas where outsourcing had room for improvements and (2) showed that major cost savings would come from supplier "in-plant". This case also showed a supplier base reduction with outsourcing activities, reducing from over 500 suppliers to six. Horn et al. (2013) with the case of "Ugly Twins", suggests the need to include, in TCO approaches regarding with global sourcing activities, costs of failed projects

Table 2- Cost drivers' systematization (Ellram and Siferd, 1993; Ferrin and Plank (2002)

Cost Drivers	
Ellram and Siferd (1993)	Ferrin and Plank (2002)
Management	Operations cost
	Quality
Delivery	Logistics
	Technological Advantage
Service	Supplier Reliability and Capability
	Maintenance
Communications	Inventory Costs
	Life Cycle
Price	Initial Price
	Customer- Related
Quality	Opportunity Cost
	Transaction Cost
	Miscellaneous

3. Methodology

3.1. Data Collection

3.1.1. Literature Studies

To create a good base to conduct this study, a theoretical framework was fulfilled. The results of this research were shown in the previous section, and gave the background necessary to conduct the collection of necessary data to achieve the aim of the study. In addition; it also supported and reinforced the results that are aimed with this study.

3.1.2. Project related documents

This component handed over the most quantity of empirical data for this study. The project related documents that contributed the most to this project were Bill of Materials, a tool used by the company for price calculation and Sourcing Decision Sheet.

Most of the efforts were put into treating the information coming from BOM and price calculation tool. BOM was rearranged to fit the study, creating a field for clusters, and combining all the projects under the same format to be able to find synergies. For the price calculation tool, since it is a tool developed for the company, understanding the tool was time consuming but the data retrieved was easily understood.

3.1.3. Interviews

When developing a study in a company, interviews play an important role in data collection. In this case, mostly were made informal interviews among the purchasing department within two levels: management level with team leader and operating level with the buyers and cost analyzers.

Important information was retrieve from these interviews, as they allowed understanding in depth the problem under study. Was also this contact with sponsors within the company that enabled the understanding of the company and project related documents. Communication via email was also important, since it was the most quick and effective way to place questions and receives answers keeping the information stored. In addition a weekly meeting with a department responsible was conducted in order to follow and adjust the evolution of the study.

3.2. Theoretical Framework of Methodology

Currently the company already uses the Total Cost of Ownership from a supplier selection perspective, however due to the constant change in the industry and challenges' growth, the idea of a possible global sourcing for its new mechatronic line components came to the table. The proposal for the study was to evaluate if a TCO approach can be considered and also identify possible markets where savings could be incurred.

Ellram (1995a) suggests that when dealing with make or buy decision, an incremental cost analysis should be performed and for that, all the costs incurred in purchasing must be identified and analyzed. When thinking about Global sourcing, it is important to get an overview also how the changes in complete acquisition of a component process will affect the cost associated.

This methodology suggested by Ellram (1995a) is applied from an outsourcing perspective, however, direct connections to global sourcing decisions were identified and due to that the methodology was used as a base for the study. Ellram (1995a) also suggests TCO for a good understanding of the costs when dealing with a specific supplier and with that the following steps for a good evaluation:

1. Define Purchasing Process
2. Identify key costs elements
3. Identify affected costs
4. Cost Breakdown analysis

In the first step, the purchase process must be identified. The objective is to avoid forgetting important costs that are related to each activity and not so easy to identify at first sight. The tendency is to overlook on costs that are involved with logistics or order processing and only focus on part price. Secondly, the key costs elements with a potential impact must be identified. Thirdly, the costs that may be affected with the change of purchase concept must be identified and accounted for the change. In addition an explanation on how they are affected and how this change is calculated should be evaluated. In this methodology, the cost elements evaluated price, transportation, interest, obsolescence and support.

Finally, the results can be evaluated under a cost breakdown perspective, where savings might be shown easily. This cost breakdown must show the cost drivers under analysis. When developing a TCO tool some aspects must be considered based on its functionality, especially when the target is to be used in a company

3.3. Methodology adaptation to practical case

The methodology explained before was applied to the current case study, using the constructive research as a base to formulate the steps to undertake. In addition, TCO approach from Ellram (1995a) was adapted in order to let us achieve our two goals, analyze if the current Total Cost of Ownership model can be applied to Global sourcing activities and to identify possible markets to source parts globally (Figure 2).

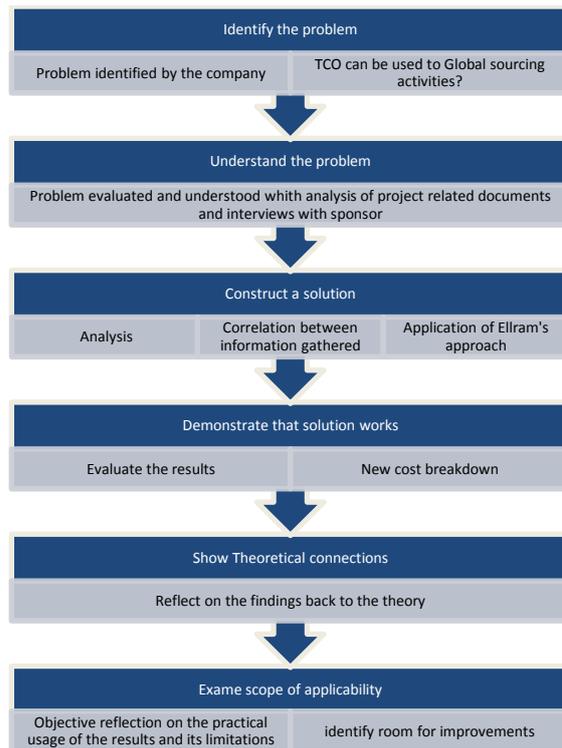


Figure 2- Research steps of the methodology used

The problem was identified and presented to the student by the company. The desire from the company to start a global sourcing strategy comes from the everyday challenges, result of the high competitiveness of the automotive industry. In addition, with this new line and also a components supplier selection, not usual in this business unit, a need of a better understanding of the possible markets is needed. For us to understand the problem, a large part of the time efforts were dedicated to company related documents so it would be possible to identify markets where the company might be interested to work in, and also to understand the strategy needed. In parallel project related documents were also time-consuming to analyze.

As mentioned in the case study description, two variants belong to this product and it also has different projects, once each part is adapted to a specific car, most of the information was not correlated between projects and variants, and one key of the study started to correlate all the BOMs in order to find synergies between the parts, which also would affect the volume searched. From this document a sourcing map from tier 2 was made to help us have a picture of the current sourcing area and its weights on the final volume purchased. Data regarding with suppliers location was collected for a better understanding of the current sourcing map,

and an analysis ABC was developed so as to identify part groups with higher impact on the final piece cost.

When applying the Ellram's suggested methodology, the steps done were as described on Figure 3. The goal with this approach was to understand how the change of the purchasing strategy would affect the TCO tool already existing. And if yes, which changes should be done to the tool and also which points can be carried out. The adaptation from Ellram's original methodology happens when we analyze the current TCO tool under the perspective of the key cost drivers of the current activities. This analysis will help us when a reflection on whether the tool is applicable or not when dealing with a new purchasing activities flow, in this case, global sourcing activities.



Figure 3- Adaptation Ellram's study model

Part of the conclusions taken to this first goal, which was to prove or deny the applicability of the TCO tool to global sourcing activities were taken from the methodology developed to achieve the second goal of this study, to identify markets and its possible cost savings from a TCO approach for specific parts. In this phase, a combination between the idea that a TCO approach must be based on an increment of costs based on activities that generate the costs (Ellram, 1995a), the sponsor expectation from the results and the empirical data available, generated a sequence of activities that links data achieving a specific result. These results also help on the reflection on whether a TCO approach can be used for global sourcing activities.

In a second phase of the study, the goal was to evaluate in which markets would be possible to identify savings based on local prices. The major cost drivers for this change would be wage costs and energy costs, pointing to a clear evaluation needed - the impact on production costs when dealing with global sourcing under a TCO approach. To investigate this perspective, a deep understanding of the data was needed to be created and also a correlation of information coming from different sources such as the Bill of Material (BOM), company's price calculation tool, Sourcing Decision sheet (SDS), company Based Prices and Markets (Figure 4).

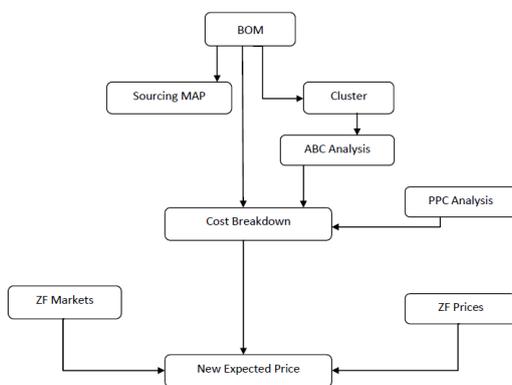


Figure 4- Data flow

Most of the data came from the BOM, where we could find information regarding price, quantities and suppliers for each part. However each project program had an individual BOM, and from

that perspective, finding opportunities in common parts for more than one program was not possible. The first challenge was to create a common BOM for the complete project, including all the program parts (including dual programs and central) in one single document, where we had a better view of which parts are program-specific, and which parts are shared by two or more programs. From this format, it was easier to have an overview from the current supply situation, making it possible to create a sourcing map for the Tier 2 suppliers. Moreover, it was needed to classify the parts into specific part groups, so for that we used a clustering approach. The clusters considered were suggested by the company's commodity department and based on the production process, being divided into the following groups: Castings, Machining, Electronics, Sheet Metal Forming, Bearings, Forgings, Powder Material, Chemical related and Various.

For this approach, only one program variant was considered, once the lifetime volumes are more representative but the extension of the results to the dual system programs will be assessed. The amount of data and results that would be achieved with the study would be too high, when applied to every cluster, and for that reason and ABC analysis was made to identify part groups with higher impact on final piece cost. For the ABC analysis, a careful data treatment was carried, in order to have the information about all piece prices, and an overview of what parts are unique for one project, or if they are shared by two or more, as previously said. Data regarding with lifetime volumes were also collected.

The first connection with the theoretical approach appears when we create a cost breakdown structure for the chosen Clusters to be under analysis. A Cost breakdown structure for the clusters selected gives us a better perspective where savings can be yielded, comparing the cost blocks with highest impact on final cost with regions costs where it is produced. Here, our goal was to have a clear picture on what impact has each cost element on final price, being the cost elements under analysis Production, Logistics, Amortization, Overheads, Labor and Material. For this step, besides information of the final piece price of the component, the theoretical split for each cost element was retrieved out of Perfect Pro Calc tool. Data from several components was analyzed, allowing us to create an overview of the weight in percentage of each cost element per cluster group.

As explained before, the goal from the company was to get a picture of which markets would create savings from the wage and energy cost reduction, and from that perspective, the cost elements that would be affected in our study would be Labor and Production as the main cost drivers will be lower, Final price as a reaction of a change of Labor and production costs (table 3).

Table 3- Cost elements under analysis

Cost Element	How affected	How Calculated
Final Price	Renegotiated	Old price vs price affected to possible lower costs
Labor	Lower wages	Old labor cost minus the savings due to lower wage
Production	Lower Energy cost	Old production cost minus savings due to lower energy cost

In order to carry on with this study, was necessary to gather information about markets available and prices related to those markets. As known before in this study, company is a global player, as most of their decisions to enter markets are purely strategic, however in these case, opening doors to new markets was not the main goal, since from the cost perspective when you are buying components, we would benefit from having this sourcing actions where the company already has activities and we could benefit from the infrastructure. For that fact, the markets

chosen where taken from company Markets database as well as the prices for wages and energy. With this information we were able to identify savings for Labor comparing the new markets with the current sourcing area. With this savings identified, we were able to clearly identify the new part prices for each selected new market (Figure 5).

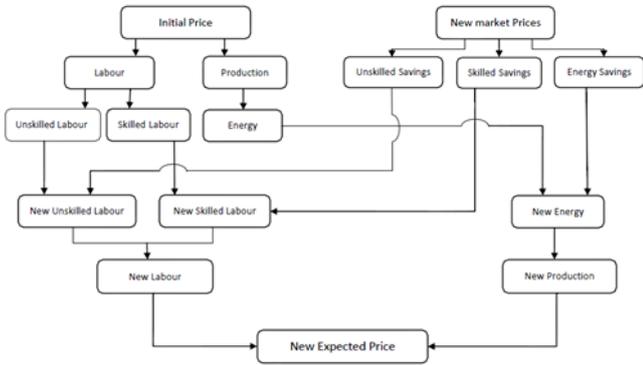


Figure 5- New Price calculation

4. Methodology Application and Results

The methodology and results are divided into two main phases, result of the two different goals of the study. In the first phase, an evaluation of the applicability of the current TCO's company approach, when dealing with Global sourcing activities. For this, a relation between the new purchasing process and the costs currently considered in the TCO tool available in the department was made.

In the next phase, an evaluation of possible savings for some specific parts will be evaluated, and for this study a deep data retrieve and treatment was done and explained. In addition the steps to achieve the final results will be explained. The results of this study will fall into a critic of some new expected prices depending on the country where each part would be sourced. These new prices are result of a recalculation after identifying the cost drivers to be evaluated and understanding how they would be affected with the change of sourcing region.

4.1. First Phase

4.1.1. Analysis of acquisition process

In the first phase of this case study, the main goal is to criticize the applicability of the current TCO tool used by the company under study. Under a TCO analysis, the final price is more than the piece price; it is a price considering all the costs associated to the purchasing process. For this, it was created a purchasing flow in order to ensure that all the costs are considered (Ellram, 1995). This purchasing flow will summarize the main activities involved in a global acquisition, and with this, the costs expected to be affected with the change from local sourcing to global sourcing were identified (Figure 6).

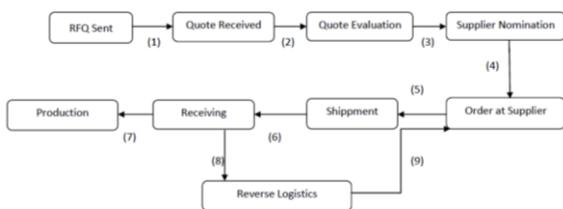


Figure 6- Global purchasing flow

In the Global purchasing flow (Figure 6), the numbers added between each activity represent costs concerning the execution of each activity. In table 4 will be analyzed which costs are identified to suffer a change (increase or decrease) and how are they affected when changing from local sourcing to global sourcing. In addition, a comparison with a current TCO tool was made, identifying all the costs that would be covered in global sourcing or not.

Table 4- Affected Costs

Point	Transaction	How costs are affected	Covered in TCO
1	RFQ Sent to Quote Received	-	-
2	Quote Received to Quote Evaluation	• Increase of Overheads	• Supplier info • Quality costs • One time Payments
3	Quote evaluation to Supplier Nomination	• Increase of Overheads	• Supplier info • Quality costs
4	Supplier Nomination to Order at Supplier	-	-
5	Order at Supplier to Shipment	• Longer demand forecast	• Not covered
6	Shipment to Receiving	• Increase of Lead times • Higher logistic costs	• Logistic costs
7	Receiving to Production	• Incoming inspection	• Quality costs
8	Receiving to Reverse Logistics	• More complex reverse logistics chain	• Not Covered
9	Reverse Logistics to Order at Supplier	• Different Reverse Logistics	• Not covered

From a general point of view, the tool is prepared to assess global sourcing activities; however some improvements must be done in order to get a more feasible result. As strong points we can see that most of the new costs can be taken into consideration in the tool, such as, overheads from the increase of efforts to evaluate a new supplier, and the major changes on logistic costs. As majors pitfalls are the inexistence of calculation of the impact of reverse logistics in the final price and not considering the impact of the risk of sourcing activities in low costs countries in the final price.

When dealing with global sourcing activities, additional efforts must be considered to fill the data into the tool, and a good teamwork between departments is crucial for a good final assessment. Even if the possibility to insert information is available in the tool, it is necessary to collect the data to insert, and in some cases, even though the tool is used, it is not used completely and considering all the costs involved.

4.2. Second Phase

At a first approach to the problem, the need of having a clear picture of the sourcing situation was addressed, so data related with current suppliers' localization was collected, reinforcing the idea that local (German) suppliers lead the list of suppliers for the entire dual system. This fact was previously justified earlier in chapter 2, and these results confirm what was already expected. For a better picture, it is recommended that in future work, data regarding with tier 3 suppliers location to be searched.

When all the new costs for labor and energy were gathered, a new price calculation framework was built (Table 5), where the expected savings were applied to the original price. As logistic impact with Global sourcing was not in this study scope, the prices used were prices without Logistic component in a first approach (Table 6)

Table 5- New Price calculation Framework

Portion	Calculation method
Part name	-
Markets name	-
Current price	BOM price
Unskilled costs	€/piece = % unskilled cost*current price
Skilled costs	€/piece = % skilled cost*current price
Production costs	€/piece = % production cost*current price
Energy cost	€/piece = % energy*production costs
New Labor costs	€/piece = (%savings unskilled*unskilled costs)+(%savings skilled*skilled costs)
New Production costs	€/piece = (%savings energy*energy cost) +production costs-energy costs
Expected New Final Price	€/piece = current price- unskilled costs- skilled costs-production costs+ New Labor costs+ New Production costs
% Reduction	€/piece= 1-(Expected new final price/current price)

Table 6- Additional Logistic costs

Portion	How calculated
Transport costs	€/piece=From Logistic Department
Packaging	€/piece=From Logistic Department
Final Logistics costs	€/piece= Transport costs+ Packaging+(%customs*Expected new final price)
Old price with Logistics	€/piece= current price+ Logistic costs (price calculation tool value)
New Final Price with Logistics	€/piece=Expected new price+ Final Logistic costs
Savings	€/piece=1-(New Final Price/Old price with logistics)

After applying the new costs to the previous found ones (Expected New Final Price), we achieved complete new results, showing us the impact that logistics might have on the final price and possible savings.

4.3 Results

Castings

From the cost breakdown analysis it was possible to notice that production cost block has a significant impact on the final costs, approximately 34%. From this perspective, it was expected that countries with lower energy costs will benefit from higher savings, however, since the weight of the energy on the final production costs is only 10% for castings, the impact ended up to be not as high as expected. In contrast, Labor represented only 15% of the costs, but in some markets we could identify reduction of labor costs near to the maximum, such as markets as Brazil with savings around 90% and India with 97%. This drastic reduction ended up to be more significant on the final price reduction.

For different parts within castings, Housing and Housing Cover both for Audi and GM programs, the reductions on the final price point us to a clear direction, India with a potential reduction of 15%, results of a drastic labor costs reduction. China and Brazil also followed the same direction, pointing to a possible reduction of around 11% of the final piece price. However, when logistics costs were applied, the overview changed, showing that the final purchasing value would actually result in possible losses. This situation shows a surprising, yet also expected scenario, that countries within Europe might represent better option when thinking about global sourcing for cost reductions. Slovenia and Turkey represented the best sourcing scenario, with savings on the final piece price and final purchasing value.

Comparing the two similar parts, housing, for both programs, we can see quite similar results. From the piece price perspective, India shows a better option with a reduction potential of 15% for both programs. However, when applying the logistics costs, European countries represent a better option, with a potential final reduction of around 8% for Slovenia and around 10% for Turkey. India also represents a good result with a positive saving of 7%.

This results show us that the importation factor has a high impact on the costs, increasing them. Another motive for this situation is the specificity of handling of these parts, which results in higher packaging costs for longer distances and not so controlled shipping environment.

Results for Housing cover analysis follow the same direction as Housing parts, with India showing a better chance for piece price reduction, but when applying logistic costs Slovenia and Turkey represent better scenarios, with savings up to 6% in Slovenia and 7% in Turkey.

Powder Metallurgy

From a cost breakdown analysis of the Powder Metallurgy cluster, we understand that savings with global sourcing will be highly unlikely due to the fact that the most representative cost block is Material, with 59% of the price. A change in the current sourcing strategy would only increase logistics that in this case represents 1.5% of the final price. Reductions in material price are difficult to achieve since it is based on material market price and a change in material would probably result in a decrease in quality.

For production, we have a contribution on the final price of 21%, so in this point we might have some savings, as for Labor with only 7% of the final price, a low impact is expected.

Currently the sourcing is done in Slovenia for the two parts chosen, Belt pulley for GM and Audi, so EUA were not considered since the costs were mostly higher than the current sourcing country.

Looking only to the reduction on the final price we can see some potential for savings, however too low compared to the impact that importation activities would have on the logistics costs. For the case of Audi Belt pulley, we can see one positive final result for Turkey, 2%, it is not sufficient to be possible to suggest it as a possible sourcing destination, but it can be a good indication in case the company is forced to look for new suppliers.

results, and decreasing the impact of a possible misleading result due to the cluster perspective.

Machining

Going again to clusters from B class, which means it has some impact on the final project costs, the cost breakdown shown good changes for production, with 34% of impact on final cost and Labor with 23%. When we have changes for savings in labor close to 100%, Brazil and China with 80%, India with 97%, Turkey with 78%, a high decrease on the labor costs are expected. In addition, production cost would also react to the energy cost decrease, since it represents close to 10% of the final production costs.

From the previous results, this cluster showed the best opportunities for Global sourcing, with only negative case in Canada. The savings went up to 25% reduction on final piece price, and with logistics included, reductions up to 19% were possible. The fact of this type of parts does not pay customs, revealed a decrease on the impact of logistics. Also the packaging costs are not so high compared with castings, once this parts are not so quality sensitive.

Although the results of this group were quite positive, an opposite result appeared when analyzing the last parts of this cluster. Distance ring revealed results similar to C parts. The reason for this result is the fact that this is a case of parts that, from the price and size perspective, would be considered as a C part, however, it is included in a production cluster mostly composed by B class parts. These parts have a unitary price quite low, and the size is also small. The impact on the final price would never be high, and having longer distances to be shipped would create a worst case than the current local sourcing.

Forgings

Lastly, forgings cluster was analyzed. From a cost breakdown point of view, production revealed a higher impact compared with all the other clusters, with a 49% impact on the final costs, however, labor only 13%, with this in mind; the perspective for better results are for countries with higher savings in energy, for example EUA, India and Turkey.

However the current sourcing location for this parts is Slovenia, which is already a low cost country, and with this, EUA are excluded from the scenario, since the overall costs are higher, leaving us with the only country showed in the past as an alternative to Slovenia, Turkey, with a piece price reduction up to 3% for GM program, and for Audi, no other country is a feasible choice.

5 - Limitations of the Study

When looking back at the application of the methodology and achieved results, we can identify some major limitations, whether in the data used or in the methodology used itself.

Logistic costs - these costs have a high impact on the final result, a more extensive study of these costs should have been done. However, since this study was made under the supervision and responsibility of the purchasing department, a more comprehensive support from logistics was not possible. A logistic evaluation under a Global Sourcing perspective requires some efforts regarding time since points like transportation costs, packaging costs considering longer transfer times, impact on the warehouse costs due to longer lead times and increase of stock must be considered, and in addition, evaluation of possible synergies due to aggregate shipping volumes.

Price calculation values - it was noticed during the analysis of the generated reports that not all the parts had the same level of input's accuracy. This fact also limited our choice on the parts to be analyzed.

Cluster perspective - may lead to an over generalization of the results. A specific analysis to each component could reinforce the

Besides the data, it is possible to identify limitations on the methodology in two main points: Quality and Risk.

When speaking about global sourcing, usually low wages countries are considered for these activities; however these countries also might have increased risks, usually related to quality and logistics. Quality since the parts quality might decrease due to underdeveloped production processes or quality inspections and logistics, due to the increased distance between supplier and destination location. If the idea is to keep the TCO approach, the company might have to develop a process to estimate the risk in a quantitative way, so the direct impact on the cost can be evaluated.

The quality portion is also not considered in this methodology, and it is seen as a limitation. This study was made under a cost reduction point of view, but with the increase of logistic costs, for not so expensive parts, global sourcing loses its purposed, however and gain in quality might be found. This could be a perspective that could have changed the results for the C components.

The methodology used shows to be effective when dealing with higher piece price components, since piece price reduction was the main target, and due to that, the effectiveness on lower price parts was not so evident.

6. Conclusions and further studies

This study was developed within a real company with the objective to start global sourcing activities to their new mechatronic product. For that the two main goals were to evaluate the applicability of the current TCO tool for global sourcing and to assess which markets could represent cost reductions.

A methodology for the research was developed. For the research, constructive approach was used, and having that in mind, a proposal for TCO studies for outsourcing decisions was adapted to the Global Sourcing goal of the company. The methodology was divided into two phases. The first phase was used to evaluate the applicability of the current TCO tool existent in the company. In the second phase, the goal to identify which markets could result into a price reduction.

The TCO tool revealed to be well prepared for the global sourcing activities, However investigations of the impact of the low cost countries risk should be done and represented in the final price. Also reverse logistics are not considered in the tool, and even for local sourcing, this should be considered.

As a main focus, B class components were chosen, Castings and Machining. After recalculating the price, both clusters showed a good reaction to a change of sourcing markets, both with good chances for price reduction. In addition, two C class clusters were chosen to comparison, Forgings and Powder Metallurgy. Starting with the worst case scenario, powder metallurgy revealed no chances for savings. For forgings, a similar case happened, not showing good changes in global sourcing activities.

For further studies, we suggest that deep analysis of the logistics chain should be done, in order to try to decrease the impact of these costs on the final price. Also a risk assessment should be done when dealing with low cost countries, because usually quality issues and lack of professionalism can lead to higher unplanned costs.

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